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AVOIDING THE CASSANDRA COMPLEX: IMPROVING WARNINGS AND NOTIFICATIONS FOR PEOPLE WITH FUNCTIONAL AND ACCESS NEEDS

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AVOIDING THE CASSANDRA COMPLEX: IMPROVING WARNINGS AND NOTIFICATIONS FOR PEOPLE WITH FUNCTIONAL AND ACCESS NEEDS

by

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December 2020

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How can emergency alerts be modified to more effectively serve people with functional and access needs? This thesis employed a qualitative analysis of three U.S. and two international case studies of disasters, applying the findings to the value proposition framework, which considers the warning requirements of people with disabilities or other access needs as well as what inclusive warning and notifications systems would look like. This framework drove eight recommendations that stakeholders can use to improve such systems. Alert originators and professional associations should enhance inclusive planning and education and implement broader use of diverse warning systems for public safety and the public. They should also leverage assistive technologies and community relationships. The Federal Emergency Management Agency (FEMA) and the U.S. Department of Homeland Security Science and Technology Directorate, respectively, should incentivize inclusive warning programs through grant funding and fund technology research for resilient warning infrastructure.

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AVOIDING THE CASSANDRA COMPLEX: IMPROVING WARNINGS AND NOTIFICATIONS FOR PEOPLE WITH FUNCTIONAL AND ACCESS NEEDS

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ABSTRACT

How can emergency alerts be modified to more effectively serve people with functional and access needs? This thesis employed a qualitative analysis of three U.S. and two international case studies of disasters, applying the findings to the value proposition framework, which considers the warning requirements of people with disabilities or other access needs as well as what inclusive warning and notifications systems would look like. This framework drove eight recommendations that stakeholders can use to improve such systems. Alert originators and professional associations should enhance inclusive planning and education and implement broader use of diverse warning systems for public safety and the public. They should also leverage assistive technologies and community relationships. The Federal Emergency Management Agency (FEMA) and the U.S. Department of Homeland Security Science and Technology Directorate, respectively, should incentivize inclusive warning programs through grant funding and fund technology research for resilient warning infrastructure.

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LIST OF ACRONYMS AND ABBREVIATIONS

While this thesis employs acronyms, they are limited for the sake of readability. Below are acronyms that are important within the context of warnings and notifications. The U.S. Department of Homeland Security's acronyms list is also helpful; see https://www.dhs.gov/terms.

ADA	Americans with Disabilities Act
CONELRAD	Control of Electromagnetic Radiation
FEMA	Federal Emergency Management Agency
FCC	Federal Communications Commission
NEMA	National Emergency Management Association
PKEMRA	Post Katrina Emergency Management Reform Act
RCMP	Royal Canadian Mounted Police
WEA	Wireless Emergency Alerts
Wireless RERC	Wireless Inclusive Rehabilitation Engineering Research Center

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EXECUTIVE SUMMARY

Emergency management and public safety practitioners cannot foretell the future, but they are often the first to know about impending hazards that require a public response to ensure safety. Thus, they possess information about present or future hazards that the public does not likely have, yet information must be communicated rapidly for it to be understood, believed, and acted upon. They also possess the expertise to predict how future events might play out if the public does not heed their warnings, based on knowledge of the past. Therefore, emergency managers fear—as did Cassandra of Troy—that while they can predict disaster outcomes, their warnings might be ignored.[1] Public safety and emergency management personnel, especially at the local level where disasters begin and end, are charged with making split-second decisions to maintain the safety of their communities.

By the end of the second decade of the twenty-first century, the United States had greatly improved its capabilities to warn citizens in times of emergency and disasters. Federal, state, and local levels of government had all contributed to such improvements. One such warning platform is the Integrated Public Alert and Warning System, which includes warnings via Wireless Emergency Alerts and the Emergency Alert System through numerous communications channels.[2] Governmental alerting authorities use the system to send emergency messages in text format via cellular networks to individuals likely to experience the impact of dangerous situations or disasters.[3]

Additionally, many local governments have implemented mass notification systems that warn registered users via calls or texts of pending threats or disasters. Despite

[1] *Encyclopedia Britannica*, s.v. "Cassandra," February 14, 2019, https://www.britannica.com/topic/Cassandra-Greek-mythology; Shankar Vedantam et al., "Warnings, Warnings Everywhere: Why We Sometimes Ignore Looming Disasters," Hidden Brain, January 20, 2020, https://www.npr.org/2020/01/17/797357603/the-cassandra-curse-why-we-heed-some-warnings-and-ignore-others.

[2] "IPAWS Architecture," Federal Emergency Management Agency, 2016, https://web.archive.org/web/20190506084227/https://www.fema.gov/media-library/assets/documents/113642.

[3] "Wireless Emergency Alerts (WEA)," Federal Communications Commission, December 19, 2019, https://www.fcc.gov/consumers/guides/wireless-emergency-alerts-wea.

the widespread use of these advanced systems and others, they do not adequately accommodate Americans with functional and access needs, such as the disabled and the elderly—a vast segment of the population. Indeed, according to 2010 U.S. Census data, roughly 20 percent of the populace has functional needs.[4] While this statistic represents a large portion of the population, it does not even include people who may have limited or no ability to communicate in English, a population that also has difficulty understanding alerts. Although designed to save lives, myriad barriers limit the effectiveness of emergency alerts for this large segment of the U.S. population.

A review of the literature suggests that shortfalls remain within the U.S. warning systems, gaps that are especially salient for people with functional and access needs. These shortcomings, displayed through academic work and cases of real-world incidents, represent the motivation of this thesis. Correspondingly, this thesis aims to find actionable solutions to improve the status quo of warnings for those who have additional barriers.

This thesis employs a qualitative analysis of the history of warnings and notifications within the United States and three U.S. disaster case studies: the 2017 Oroville Dam Evacuation, the 2017 and 2018 California wildfires, and Hurricane Harvey in 2017. Additionally, it presents two international warning case studies, reviewing the warning methodologies and inclusivity practices of Canada and New Zealand. The U.S. case studies identify gaps in public education, outreach, and planning; alert originator education and planning; timeliness of warnings, reliance on too few systems; Wireless Emergency Alerts (underuse); and limited resilience of current warning infrastructure. The international case studies identify the positive practices of accessible public education materials, including information on assistive technologies and building neighborhood partnerships, regular public tests of warning systems, provision of cell phones to people experiencing indigence during COVID-19, and use of non-emergency communication channels to bolster messages sent through warning systems.

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[4] "Nearly 1 in 5 People Have a Disability in the U.S., Census Bureau Reports," U.S. Census Bureau, July 25, 2012, https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html; Federal Emergency Management Agency, *Alerting the Whole Community: Removing Barriers to Alerting Accessibility* (Washington, DC: Federal Emergency Management Agency, 2013), 1, https://www.hsdl.org/?abstract&did=738561.

The findings from these case studies are applied to the value proposition framework, as developed by Alexander Osterwalder et al., which considers the needs of clients within the context of a company's functions or goods and thereby seeks to add worth through meeting those needs.[5] The idea behind the value proposition framework, as used for this thesis, is to identify the shortcomings of current warning methodologies for people with functional and access needs by considering their perspectives after careful analysis of real-world incidents. Additionally, this thesis suggests how an inclusive warning program might look, and then the value proposition framework drives the recommendations for improvement.

This thesis facilitates future action for the improvement of warnings and alerts by grouping recommendations into stakeholder categories, thereby assigning recommendations to the organizations best suited to effect change. Local, state, and federal alert originators, as well as professional association originators (the first stakeholder group), should:

- Educate constituents on warning systems and plan to meet community-specific needs.
- Educate and train alert originators.
- Use all warning tools available.
- Leverage assistive technology.
- Promote know-your-neighbor programs.
- Regularly and publicly test warning systems.

The Federal Emergency Management Agency and the Department of Homeland Security's Science and Technology Directorate (the second stakeholder group) should:

[5] Alexander Osterwalder et al., *Value Proposition Design: How to Create Products and Services Customers Want* (New York: John Wiley & Sons, Incorporated, 2014), 6–9.

- Incentivize emergency management planning functions with vulnerable populations through federal grant funding.
- Conduct further research into resilient warning infrastructure.

These recommendations directly address the identified shortcomings from the case studies.

The year 2020 has illustrated the need for effective warning systems; those in public safety and the homeland security enterprise are loath to be like Cassandra—doomed to predict a dire future yet to have their warnings go unheeded. If current trends continue, there will be no shortage of hazards about which to warn the public. Investments of time, energy, and funding are vital in this arena, as such expenditures will pay dividends across all hazards and across all segments of the population, including the most vulnerable.

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It is with sincerest gratitude that I write this passage, as my time in the Naval Postgraduate School's Center for Homeland Defense and Security (CHDS) master's program has vastly changed the lens through which I view the world. I am thankful for all of the following people, who made this endeavor possible. First and foremost are my wife, Alison, and daughter, Clara, who have gone without me at numerous family functions and bedtime routines. Second, the team at the Delaware County Office of Homeland Security and Emergency Management, who picked up the slack when I was engaged with school activities. Third, the Delaware County Office of Homeland Security and Emergency Management Executive Committee trusted me enough to approve this undertaking and have been supportive throughout the process. Last, but not least, the faculty, staff, and contractors with CHDS, along with my fellow students in cohorts 1903/04, who made this program the singular educational experience that it is.

I hope that this thesis, at least in some small way, contributes to the national dialogue on serving the most vulnerable. It is dedicated to my parents, John and Mary Jean, who sacrificed much on my behalf.

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I. INTRODUCTION

Emergency management and public safety practitioners cannot foretell the future, but they are often the first to know about impending hazards that require a public response to ensure safety. Thus, they have information about present or future hazards the public does not likely have, yet information must be communicated rapidly for it to be understood, believed, and acted upon. They also possess the expertise—the gift, one might say—to predict how future events might play out if the public does not heed their warnings, based on knowledge of the past. Therefore, emergency managers fear—as did Cassandra of Troy—that while they can predict disaster outcomes, their warnings might be ignored.[1]

Public safety and emergency management personnel, especially at the local level, where disasters begin and end, are charged with making split-second decisions to maintain the safety of their communities. Incident circumstances may dictate that such personnel make decisions that affect life safety based on rapidly evolving, incomplete, or conflicting information at the least opportune time. Life-safety decision-making at the local level includes decisions about if and when to issue warnings and notifications to the public.

Imagine a small community suddenly faced with a rapidly advancing wildfire, or the imminent failure of a large upstream dam, at two o'clock in the morning. Local incident commanders immediately call for evacuations of the soon-to-be-devastated areas. Then, emergency telecommunications and emergency management personnel must warn the public—the whole community—while avoiding Cassandra's curse. The whole community includes people and groups that may have numerous barriers to receiving, understanding, and acting upon the warnings. This thesis seeks to guide efforts to mitigate warning barriers for people with functional and access needs.

[1] *Encyclopedia Britannica*, s.v. "Cassandra," February 14, 2019, https://www.britannica.com/topic/Cassandra-Greek-mythology; Shankar Vedantam et al., "Warnings, Warnings Everywhere: Why We Sometimes Ignore Looming Disasters," Hidden Brain, January 20, 2020, https://www.npr.org/2020/01/17/797357603/the-cassandra-curse-why-we-heed-some-warnings-and-ignore-others.

A. RESEARCH QUESTION

How can emergency alert systems be modified to more effectively serve people with functional and access needs?

B. PROBLEM STATEMENT

By the end of the second decade of the twenty-first century, the United States had greatly improved its capabilities to warn citizens in times of emergency and disasters. Federal, state, and local levels of government had all contributed to such improvements. Currently, numerous government agencies at all levels send alerts through different systems to inform the public of peril. One such warning platform is the Integrated Public Alert and Warning System, which includes warnings via Wireless Emergency Alerts and the Emergency Alert System through numerous communications channels.[2] Governmental alerting authorities use the system to send emergency messages in text format via cellular networks to individuals likely to experience the impact of dangerous situations or disasters.[3] Additionally, many local governments have implemented mass notification systems that warn registered users of pending threats or disasters via calls or texts. Despite the widespread use of these advanced systems and others, the systems do not adequately accommodate Americans with functional and access needs—a vast segment of the population. Indeed, according to 2010 U.S. Census data, roughly 20 percent of the populace has functional needs.[4] While this statistic represents a large portion of the population, it does not even include people who may have limited or no ability to communicate in English, a population that also has difficulty understanding alerts.

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[2] "IPAWS Architecture," Federal Emergency Management Agency, 2016, https://web.archive.org/web/20190506084227/https://www.fema.gov/media-library/assets/documents/113642.

[3] ""Wireless Emergency Alerts (WEA)," Federal Communications Commission, December 19, 2019, https://www.fcc.gov/consumers/guides/wireless-emergency-alerts-wea.

[4] "Nearly 1 in 5 People Have a Disability in the U.S., Census Bureau Reports," U.S. Census Bureau, July 25, 2012, https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html; Federal Emergency Management Agency, *Alerting the Whole Community: Removing Barriers to Alerting Accessibility* (Washington, DC: Federal Emergency Management Agency, 2013), 1, https://www.hsdl.org/?abstract&did=738561.

People with functional and access needs, including those with limited English proficiency, experience barriers to emergency alerting for numerous reasons. One reason is that many alerts and notifications come from small local government entities, usually counties, which can create gaps in effective alerting.[5] These local governments typically have fewer staff members and less funding than entities at the federal or state level, which creates barriers in preparing emergency alerts. Indeed, the National Academies of Sciences, Engineering, and Medicine acknowledge the resource and personnel variations among alerting authorities.[6] According to data collected by the creators of Hyper-Reach, a mass notification system, only about one in five counties in the United States had registered to use wireless emergency alerts as of 2017, and the counties that had registered used the alerts infrequently.[7] This situation demonstrates that local entities are not using available alerting resources to their full potential, which creates warning shortfalls.

Furthermore, people with functional and access needs may not have all the same resources that are available to the general population during disasters. More specifically, emergency notifications may be less effective for these populations as they often lack the robust social support of the general population.[8] Warning message validation matters because, according to Michele Wood et al., "historical research has shown that when provided with warning information about an imminent threat, people tend to seek additional information and confirm information already received before they act, thus 'wasting' time before initiating a protective action."[9] If people with functional and access

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[5] "Organizations with Alerting Authority Completed," Federal Emergency Management Agency, December 16, 2019, https://web.archive.org/web/20190401000000*/https://www.fema.gov/media-library/assets/documents/117152.

[6] National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems: Current Knowledge and Future Research Directions* (Washington, DC: National Academies Press, 2018), 74, https://doi.org/10.17226/24935.

[7] "A Closer Look at IPAWS," Hyper-Reach, December 22, 2017, https://www.hyper-reach.com/lets-get-more-jurisdictions-on-ipaws/; Hamilton Bean, *Mobile Technology and the Transformation of Public Alert and Warning* (Santa Barbara, CA: Praeger Security International, 2019).

[8] National Council on Disability, *Effective Communications for People with Disabilities: Before, during, and after Emergencies* (Washington, DC: National Council on Disability, 2014), 39–40, https://rems.ed.gov/docs/Effective%20Communications%20for%20People%20with%20Disabilities.pdf.

[9] Michele M. Wood et al., "Milling and Public Warnings," *Environment and Behavior* 50, no. 5 (2018): 536, https://doi.org/10.1177/0013916517709561.

needs are less apt to confirm alerts, then there may be an even greater lag between the time the message is received and the time they take action. The National Academies of Sciences, Engineering, and Medicine support the idea that the traits of a warning message recipient, such as functional or access needs, could affect the time it takes the recipient to adhere to the alert.[10]

The technology itself can prove problematic as well. For example, another hindrance for this population lies in the use of mobile devices, which appear in roughly 9 percent fewer homes of those with functional and access needs than of the general population.[11] Thus, people with functional and access needs may receive wireless emergency alert messages at a lower rate; even if the alerts are received, they may not be as effective in spurring adherence to message instructions. Moreover, while the system can send English- and Spanish-language messages, they will be ineffective for many people with limited or no proficiency in these languages.[12] Furthermore, the utility of the system messages is hampered by their largely text-based format, which can be problematic for people with vision disabilities.[13] These and other barriers matter because they limit the effectiveness of emergency alerts—which are designed to save lives—for a large segment of the U.S. population.

C. LITERATURE REVIEW

The most pertinent literature in this area came after approximately 2010, when the national dialogue included more on wireless alerts; however, some studies and documents published before that time are quite illuminating on the subject. The literature that supports

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[10] National Academies of Sciences, *Emergency Alert and Warning Systems*, 37.

[11] John T. Morris and W. Mark Sweatman, "Wireless Device Ownership by People with Disabilities," *SUNspot* 2016, no. 1 (December 2016): 3; Monica Anderson, "U.S. Technology Device Ownership 2015," Pew Research Center, October 29, 2015, https://www.pewresearch.org/internet/2015/10/29/technology-device-ownership-2015/.

[12] "Just Announced at IAEM: WEA 2.0 & 3.0 Roll Out Date, November 29th," Federal Emergency Management Agency, November 19, 2019, https://content.govdelivery.com/accounts/USDHSFEMA/bulletins/26cf4aa.

[13] Wireless Inclusive Rehabilitation Engineering Research Center, "FM Radio and RBDS-Based Emergency Alerting" (paper brief, Georgia Tech, 2018), 1, http://www.wirelessrerc.gatech.edu/paper-brief-save-lives-withstand-catastrophe-and-stimulate-marketplace; Federal Emergency Management Agency, "WEA 2.0 & 3.0 Roll Out Date."

this thesis generally falls into one of three categories: warning and notifications studies and documents that focus on the general public but may touch on people with functional and access needs, preparedness literature and studies for people with functional and access needs, and research that focuses solely on warnings and notifications for the aforementioned people who may have additional barriers. The latter category, while containing some solid work by a few institutions and individuals, is by far the scarcest of the three. The literature is composed primarily of practitioners' documents, such as best practices, reports, lessons learned, academic studies, and scholarly articles.

1. Definitions

This thesis uses the term *functional and access needs* to describe people who may have additional barriers in receiving alerts. This includes the elderly, people with limited ability to communicate in English, and those with disabilities as defined by the Americans with Disabilities Act (ADA). The ADA defines disability as a "physical or mental impairment that substantially limits one or more major life activities."[14]

Another important definition is that of *alert originators*. These are government entities at the federal, state, or local level that have the authority to send warnings and notifications to the public in times of emergency or disaster. This is a term frequently used in warning literature and is used interchangeably with *alerting authorities*.

This thesis focuses on warnings and alerts and uses Department of Homeland Security definitions pertaining to different types of communications, as shown in Table 1.[15]

[14] Americans with Disabilities Act, as Amended, 42 U.S.C. § 12102 (2008), https://www.ada.gov/pubs/adastatute08.htm#12102.

[15] Department of Homeland Security, *Public Safety Communications: Ten Keys to Improving Emergency Alerts, Warnings & Notifications* (Washington, DC: Department of Homeland Security, 2019), 1, https://www.hsdl.org/?view&did=824825.

Table 1. Homeland Security Warnings, Alerts, and Notifications Definitions[16]

Type	Timeframe	Purpose	Examples
Warnings	Prior to incident	Distribute guidance to prepare for an anticipated incident	Weather watches/warnings, fire warnings, volcano warnings, evacuation orders
Alerts	At the beginning of and during incident with an ongoing immediate threat	Gain the attention of the public and draw their attention to a risk or hazard	Active shooter and other civil dangers, hazmat concerns, 911 outage, AMBER alerts
Notifications	During and after immediate threats	Instruct immediate protective actions and provide ongoing communications relevant to an incident to reduce milling and encourage public action. Convey time-sensitive information on response and recovery-related services	Protective actions, evacuation routes, boil water, return from evacuation notices, area accessibility updates, all-clear notices

2. Existing Research

The broad field of research about emergency alerts and notifications has grown even broader within the past decade thanks largely to the advent of Wireless Emergency Alerts in 2012.[17] The literature recognizes this system as a tremendous step forward for notifying the public in times of disaster. As such, there is no robust debate about the value of the system; however, there are ongoing discussions about how best to implement this system, including how to mitigate current system limitations and potential future upgrades to bolster its effectiveness for the whole community.

This body of literature occasionally references people with functional and access needs when discussing the alerting process. The Department of Homeland Security's Office of Cyber and Infrastructure Analysis (CISA) published one such document in 2019, and CISA suggests alert originators should be methodical and deliberate in their warning planning and implementation processes.[18] The organization presents best practices and encourages alerting agencies to "consider the use of more dynamic, visual, and spatial content, outside of text messages, to reach diverse populations, ensure accessibility, and better convey risk."[19] Less than one page of the eighteen18-page document is dedicated to

[16] Source: Department of Homeland Security, 1.

[17] Federal Communications Commission, "Wireless Emergency Alerts (WEA)."

[18] Department of Homeland Security, *Public Safety Communications*.

[19] Department of Homeland Security, 6.

this subject, and some of the practices identified are incompatible with Wireless Emergency Alerts and potentially other local mass notification systems. For example, Wireless Emergency Alerts cannot include video, pictures, or voice message components as of this writing. Indeed, the National Academies of Sciences, Engineering, and Medicine have also weighed in on this subject and found that gaps exist regarding the utility of this system for people with functional and access needs.[20] Their report highlights the long-term alerting goal of "Adapting message content and format to the context and needs of the end user—for example, considering location of the device, known home location of the device owner, language of the device owner, disability status, and other context (as selected or entered by the user)."[21] Thus, multiple government sources seem to agree that a nationwide alerting system that cannot provide multimedia formats has shortfalls in the context of accessibility.

Dennis Mileti studies this subject and recently contributed to research authored by Wood et al.[22] The authors explore how the government might exploit these systems to spur the public into following warning message guidance as soon as possible.[23] The authors evaluate ways to reduce public milling or delaying adherence to warning messages by reviewing the various ways in which the public perceives and mentally processes such messages.[24] In identifying areas for future research, they warn that "understanding ways to maximize [warning] message impact among disabled and functional limitation communities is critical to extending the benefits of warning technology to broader society."[25] Furthermore, in a Federal Emergency Management Agency (FEMA) PrepTalk,

[20] National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems*, 7.

[21] National Academies of Sciences, Engineering, and Medicine, 9.

[22] Wood et al., "Milling and Public Warnings."

[23] Wood et al., 535.

[24] Wood et al., 535.

[25] Wood et al., 558.

Mileti discusses the importance of alert message crafting and content.[26] He drives home this point:

> But, what impacts protective action initiation behavior in Americans the most? It's the message contents, it's the message contents, it's the message contents. Any questions about what the most important factor is? It's the message contents. It's what the message says and how it says it.[27]

A 2014 study by Hamilton Bean et al. reiterates the importance of and nuance in crafting actionable warning messages; the study highlights challenges with short-length warning language and describes important pieces of information to include in the messages, including the order in which they should appear.[28] For example, the authors suggest that including the name of the agency that sent the alert could help spur the public into heeding the short-length message.[29]Additionally, Bean et al. found that longer warning text (in this case, over 1,300 characters) was generally more effective than shorter text in driving public response.[30] These works demonstrate the high degree of subtlety and nuance involved in crafting effective warning messages for the general public. However, as referenced earlier, individuals who have functional needs face even greater hurdles when it comes to prompt adherence to warning guidance.[31]

Much of the current literature on Wireless Emergency Alerts focuses on how best to use the system for the general population. In response to the spurious, duress-inducing missile alert in 2018 from Hawaii Emergency Management, the Federal Communications Commission (FCC) found a "combination of human error and inadequate safeguards

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[26] "PrepTalks: Dr. Dennis Mileti 'Modernizing Public Warning Messaging,'" Federal Emergency Management Agency, February 14, 2018, https://www.fema.gov/preptalks/mileti.

[27] Federal Emergency Management Agency.

[28] Hamilton Bean et al., *Comprehensive Testing of Imminent Threat Public Messages for Mobile Devices* (Washington, DC: Department of Homeland Security Science and Technology Directorate, 2014), 1–2, https://www.dhs.gov/publication/wea-comprehensive-testing-imminent-threat-public-messages-mobile-devices-updated.

[29] Bean et al., 1.

[30] Bean et al., 2.

[31] National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems*, 37.

contributed to the false alert."[32] The commission's report recommends numerous corrective actions to prevent erroneous alerts in the future, such as using accurate language in drill messages and confirming the accuracy of alert languages using several staff members who are familiar with the system.[33] More specifically, the FCC recommends that those crafting the messages should "refrain from using phrases such as 'This is Not a Drill' or 'Real World' in test messages. Instead, test messages should be clearly identified as tests."[34]

One group of practitioners has explored ways to correct the misuse or underuse of such systems. In the context of wildfires, the National Emergency Management Association (NEMA) offers some related recommendations, recognizing that the public was potentially unsure of what action to take based on common warning messages.[35] NEMA recommends using as many warning channels as possible and encourages "regular education and training on use of [warning] technology."[36] The literature provides a consensus on the latter point. The Office of Cyber and Infrastructure Analysis highlights the importance of training for those sending warnings, and Art Botterell takes it a step further by recognizing that there is no credentialing among government warning personnel.[37]

Some of the contemporary literature looks at warnings within the context of human communication and technology. Bean contends that the main problem with wireless warning systems is that they do not effectively convey messages to people, whereas, in the

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[32] Federal Communications Commission, *Report and Recommendations: Hawaii Emergency Management Agency, January 13, 2018, False Alert* (Washington, DC: Federal Communications Commission, 2018), 14.

[33] Federal Communications Commission, 24–25.

[34] Federal Communications Commission, 24.

[35] National Emergency Management Association, "NEMA Wildfire Alert & Notification Workshop: Summary," (workshop summary, National Emergency Management Association, April 17, 2019), 6, https://www.nemaweb.org/index.php/nema-initatives/wildfire-alert-notification.

[36] National Emergency Management Association, 7.

[37] Department of Homeland Security, *Public Safety Communications*, 8–9; Bean, *Mobile Technology*, ix.

past, problems have primarily been attributed to technology.[38] This idea shows that these two aspects of alerting are not always given equal consideration by alerting authorities. Indeed, Bean later observes, "The United States does not really have a mobile alert and warning system problem—it has a public education problem."[39] One technical example is the limited message length for Wireless Emergency Alerts. The literature agrees that longer warning messages are generally more effective at spurring the public to adhere to their directions. Wood et al. support this idea, and Bean et al. acknowledge the limited effectiveness of short warning language as well.[40] The recent increase from a 90-character to 360-character limit within Wireless Emergency Alerts supports this notion.[41] The technological and human dichotomy of alerts and warnings is also referenced by the National Academies of Sciences, Engineering, and Medicine, which posits that experts in both areas are needed to study this subject.[42] While it may be helpful to analyze problems based on this dichotomy, the literature within this category offers limited actionable guidance to help warning practitioners effectively alert people who have functional and access needs.

A review of the literature suggests that shortfalls remain within the U.S. warning systems—shortfalls that are especially salient for people with functional and access needs. These shortcomings, displayed through academic work and cases of real-world incidents, are the reasons behind the research question of this thesis. As such, this thesis aims to find actionable solutions to improve the status quo of warnings for those who may have additional barriers.

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[38] Bean, Mobile Technology, xxiii.

[39] Bean, 129.

[40] Wood et al., "Milling and Public Warnings," 1; Bean et al., *Comprehensive Testing*, 1.

[41] Federal Emergency Management Agency, "WEA 2.0 & 3.0 Roll Out Date."

[42] National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems*, 9.

D. CHAPTER ORGANIZATION

This thesis contributes, through the lens of a local emergency manager, to the ongoing, robust discussion on warnings and notifications by reviewing both sides of the alerting equation: requirements for people with functional and access needs, and alerting practices of emergency management personnel. In other words, this thesis reviews where the United States' current warnings and notifications methodology falls short on the side of alert originators (those sending the alerts) and the alert consumption requirements of people with functional and access needs (those receiving the alerts). Ultimately, this thesis seeks to achieve balance between these two ends of the warning spectrum by applying the value proposition, and then suggests solutions and recommendations.

Chapter II reviews the history of electronic alerting systems in the United States, starting with civil defense–era systems of the Cold War and extending through today's current technology. This chapter also provides background on inclusive alerting. Chapter III introduces the U.S. and international case studies for this thesis and the framework for their review, the value proposition canvas. Chapter IV reviews the three U.S. case studies of disasters from which lessons are drawn within the context of inclusive public warnings. Chapter V reviews the two international case studies of inclusive alerting practices through recent incidents and public outreach and education materials. Chapter VI applies the value proposition to the lessons from the five case studies, and Chapter VII synthesizes the findings of this thesis and provides recommendations for improving inclusivity in alerting.

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II. HISTORY OF ALERTS IN THE UNITED STATES

The history of warning systems in the United States is illustrative of the threats and hazards, technology, and governmental objectives of each era. Warning methodologies started during the Cold War with rudimentary systems focusing primarily on military and some weather concerns and expanded to focus on all hazards through multiple systems, with an eye toward greater inclusivity. This chapter reviews that history.

A. COLD WAR TO PRESENT

During the height of the Cold War, the United States developed a national system for warning the public. However, warnings were not the only objective with the system, which was known as CONELRAD. As Susan L. Brinson states:

> Implemented in late 1951, CONELRAD (a contraction of CONtrol of ELectromagnetic RADiation) was conceived as a military air defense system that eventually attempted to incorporate two fundamental and incompatible goals: deny radio transmissions as a navigational aid for enemy bombers by taking radio stations off the air, while simultaneously using radio stations to communicate critical civil defense information during an attack in order to protect the civilian population.[43]

Contrastingly, today's national alerting systems are primarily an operation of civil authorities. CONELRAD, a joint effort between the Federal Civil Defense Administration (FCDA), the military, and the FCC, witnessed turf battles.[44] While the military and FCC were keenly focused on denying marauding Soviet bombers any direction-finding advantage from radio stations within the United States, the FCDA was focused on providing warnings to the public through many of those same radio stations in the event of a nuclear attack.[45]

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[43] Susan L. Brinson, "CONELRAD on the Front Line of Cold War Defense," *Media, War & Conflict* 2, no. 3 (2009): 340, https://doi.org/10.1177/1750635209345200.

[44] Brinson, 340.

[45] Brinson.

The general idea behind CONELRAD was relatively simple in theory but difficult to implement in practice. Brinson elaborates on this difficulty and discusses that the civil defense warning capability for the public was hampered by the fact that the program permitted limited radio stations to broadcast such messages, and in limited fashion, as the majority of stations first went silent to support the national defense objective.[46] Larry Burkum highlights CONELRAD's shortcomings, as well, mentioning that "[t]he plan called for all participating stations to switch to one of two frequencies, either 640 or 1240 kilohertz, and reduce their operating power to not more [than] 10,000 watts and usually less than 5,000 watts."[47] Brinson explains another problem: the delay and equipment-based difficulties in stations ceased normal broadcasts and transferred to the designated CONELRAD warning frequencies.[48] Brinson contends that limited broadcast coverage was a significant problem with CONELRAD as well.[49] Ultimately, in 1963, CONELRAD officially ended.[50] This replacement, which swiftly took its place, is known as the Emergency Broadcast System, or EBS.[51]

The advent of the Emergency Broadcast System was representative of changes in military and broadcast technology. For example, missile and navigational technologies had improved to the point of negating any benefit to U.S. national defense in silencing radio transmissions, as it was believed the Soviets could effectively attack the United States even with cessation of radio broadcasting.[52] The proliferation of television was another change; according to the FCC, by 1960 television sets were in 88 percent of American homes.[53]

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[46] Brinson, 344–45.

[47] Larry G. Burkum, "This Is a Test: The Evolution of the Emergency Broadcast System History of Radio," *Journal of Radio Studies* 2, no. 1 (1993): 143, https://doi.org/10.1080/19376529309384513.

[48] Brinson, "CONELRAD," 346.

[49] Brinson, 353.

[50] Burkum, "This Is a Test," 143.

[51] Burkum, 141.

[52] Brinson, "CONELRAD," 351.

[53] Federal Communications Commission, *26th Annual Report of the Federal Communications Commission for Fiscal Year 1960* (Washington, DC: U.S. Government Printing Office, 1960), 2, https://www.fcc.gov/reports-research/reports/annual-reports-congress/26th-annual-report-congress-1960, as cited in Brinson, "CONELRAD," 351.

Because of this proliferation, Brinson argues that television represented an untapped resource to send warnings to the American public.[54]

According to the FCC, the Emergency Broadcast System had the goal of enabling all levels of government to warn the nation during crises in an expeditious manner.[55] Much of the focus was on presidential alerting capabilities; as the FCC states, "The President requires a 5-minute capability, regardless of his whereabouts, to address the Nation following an Emergency Action Notification."[56] Thus, with this new system, the public warning and notification function was the point. Unlike CONELRAD, the Emergency Broadcast Service did not use special frequencies and incorporated both television and radio stations for warning purposes.[57]

However, technology and threats continued to evolve over the intervening decades. In 1997, the Emergency Alert System officially replaced the Emergency Broadcast System.[58] According to FEMA, this upgrade incorporated digital technology and worked with "broadcasters, cable television systems, wireless cable systems, satellite digital audio radio service (SDARS) providers and direct broadcast satellite (DBS) providers."[59] Messages sent through this system to the public included a voice message and an attention-grabbing tone.[60] Technological parallels are easily drawn between the Emergency Alert System and CONELRAD. Just as the use of television exploded during CONELRAD's time, the use of cellphones proliferated after the adoption of the Emergency Alert System.

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54 Brinson, "CONELRAD," 351.

55 Federal Communications Commission, *30th Annual Report of the Federal Communications Commission for Fiscal Year 1964* (Washington, DC: U.S. Government Printing Office, 1964), 38, https://www.fcc.gov/document/30th-annual-report-fcc-1964.

56 Federal Communications Commission, 38.

57 Federal Communications Commission, *29th Annual Report of the Federal Communications Commission for Fiscal Year 1963* (Washington, DC: U.S. Government Printing Office, 1963), 35, https://www.fcc.gov/document/29th-annual-report-fcc-1963; and Burkum, "This Is a Test," 147.

58 "Emergency Alert System (EAS)," Federal Emergency Management Agency, January 1, 2016, https://www.fema.gov/media-library-data/1465326763240-4152791226bbd49cf46aff8cd5f43bb1/Emergency_Alert_System_Fact_Sheet_2016.pdf; "The Evolution of Emergency Broadcasting," Federal Emergency Management Agency, accessed May 31, 2020, https://www.fema.gov/pdf/emergency/ipaws/ipaws_the_evolution_of_emergency_broadcasting.pdf.

59 Federal Emergency Management Agency, "Emergency Alert System (EAS)."

60 Federal Emergency Management Agency, "Evolution of Emergency Broadcasting."

Anthony Gargano highlights that cellphones represented an incredibly powerful medium through which to alert the public.[61] However, unlike in the CONELRAD story, the adoption of a new technology did not spell the end of the Emergency Alert System.

Today, the United States relies on a system called IPAWS, or the Integrated Public Alert and Warning System, of which the Emergency Alert System is still a part. Gargano perhaps saw the writing on the wall, as one of the components of the new system is the mobile alerting capability through Wireless Emergency Alerts, or WEA; see Figure 1 for all components of the system.[62]

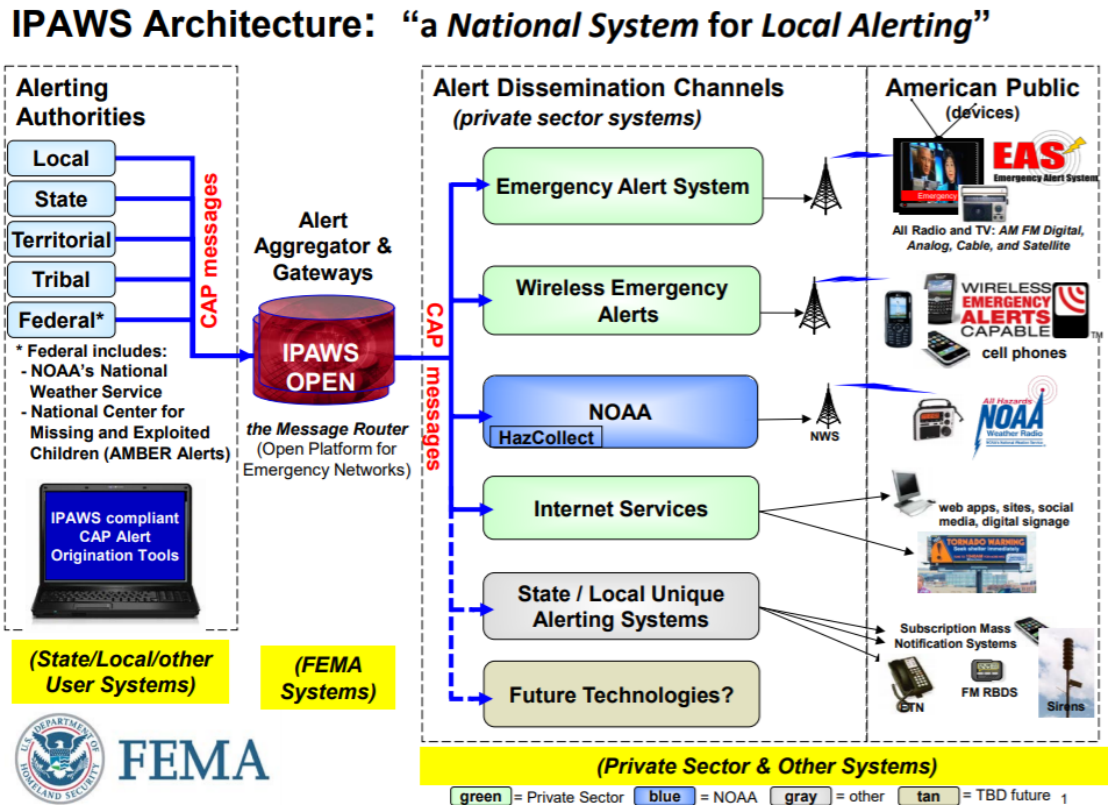

Figure 1. IPAWS Architecture[63]

[61] Anthony R. Gargano, "Emergency Alert System?" *Broadcast Engineering* 54, no. 1 (January 2012): 1, ProQuest.

[62] Federal Emergency Management Agency, "IPAWS Architecture."

[63] Source: Federal Emergency Management Agency.

B. BACKGROUND ON INCLUSIVE ALERTING AND RELATED POLICY

In the United States, inclusive alerting has had a mixed record. However, as technology has improved, so too has the inclusivity of warning systems. For example, CONELRAD relied only upon radio stations to alert the public. As such, this warning mechanism only provided an audible means of disseminating emergency information, which excluded people who were deaf. With the advent of the Emergency Broadcast System, the medium of television was added to the national alert methodology and so too was at least some visual component to alerts.[64] As time progressed, broadcasters were able to implement improvements to the technology and the Emergency Alert System eventually included digital technology; these alerts include a "digitally encoded header, attention signal, audio announcement and digitally encoded end-of-message marker."[65]

While this thesis does not include an exhaustive policy review, a few policies and acts are illustrative for this subject. The Americans with Disabilities Act (ADA), Executive Order 13407, the Post-Katrina Emergency Management Reform Act (commonly referred to as PKEMRA), and the Warning Alert Response Network Act (commonly referred to as the WARN Act) merit contemplation. Save for the ADA, these policies came in rapid succession following Hurricane Katrina in 2005 and all pertain to improving the nation's public warning capability to varying degrees.

The Americans with Disabilities Act was passed in 1990 and was updated in 2008.[66] Of particular interest is Title II, which covers state and local governments, where much of the burden for warnings and notifications rests.[67] Specifically, section 12132 says, "[N]o qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of services, programs, or activities of a public entity, or be subjected to discrimination by any such entity."[68] Indeed, several scholars

64 Federal Communications Commission, 29th Annual Report, 2.

65 Federal Emergency Management Agency, "Emergency Alert System (EAS)."

66 Americans with Disabilities Act, as Amended.

67 Americans with Disabilities Act, as Amended.

68 Americans with Disabilities Act, as Amended.

have recognized the importance of Title II of the ADA within the context of disasters.[69] Nancy Jones references that "[a]lthough the ADA does not include provisions specifically discussing its application to disasters, its nondiscrimination provisions are applicable to emergency preparedness and responses to disasters."[70] Furthermore, Angi English asserts that the high percentage of Americans with disabilities underscores the importance of compliance with the ADA for disaster communications.[71]

Executive Order 13407 was signed by President George W. Bush on June 26, 2006.[72] This document laid the administrative groundwork for what would eventually become the Integrated Public Alert and Warning System. In section 1, the order dictates that the United States and its inhabitants must have a robust, cohesive notification methodology for a wide variety of dangerous situations.[73] This same section references that an important part of such a system is the capability for the president to send significant, disaster-related information to the nation, which had been an ongoing and important role of the Emergency Alert System.[74] However, the order required several other pertinent actions as well. Section 2 places a great deal of responsibility on the secretary of homeland security for carrying out functions pertaining to this new warning methodology, such as the integration of the Emergency Alert System and an overall review of current notification and alert functionalities; it goes on to reference that the new system should operate based on the desires of the alert recipient and defined hazard areas.[75] These features are recognizable as attributes of the modern Integrated Public Alert and Warning System. The

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69 Nancy Lee Jones, *The Americans with Disabilities Act and Emergency Preparedness and Response*, CRS Report No. RS22254 (Washington, DC: Congressional Research Service, 2010), https://fas.org/sgp/crs/homesec/RS22254.pdf; Angi English, "Communicating with Everyone during a Crisis," *Medium*, February 14, 2020, https://medium.com/homeland-security/communicating-with-everyone-during-a-crisis-181585636cb4.

70 Jones, The Americans with Disabilities Act, 1.

71 English, "Communicating with Everyone during a Crisis."

72 George W. Bush, "Executive Order 13407 'Public Alert and Warning System,'" *Weekly Compilation of Presidential Documents* 42, no. 26 (June 26, 2006): 1226–28.

73 Bush, 1226.

74 Bush, 1226.

75 Bush, 1226.

order goes on to say that "the public alert and warning system [must have] the capability to alert and warn all Americans, including those with disabilities and those without an understanding of the English language."[76] Thus, there is an acknowledgment that the new system should accommodate all persons, regardless of ability.

Another relevant policy is PKEMRA, which was enacted in 2006.[77] Section 513 mandates the creation of a disability coordinator position within the Federal Emergency Management Agency.[78] This position is charged with a wide variety of functions to ensure better representation for those with functional and access needs in emergency management processes, public outreach, and education efforts; the person who fills this position is also required to coordinate with disability advocacy groups and work with industry partners so that information on disasters is disseminated in inclusive formats.[79]

Lastly, the WARN Act of 2006 mandates the creation of the Integrated Public Alert and Warning System.[80] Of particular interest is a congressional hearing on the WARN Act during which Fred Upton, in his opening remarks, describes how previous incidents displayed gaps in the United States' warning and notification methodology, including during Hurricane Katrina.[81] He goes on to state, "What we must strive for is an emergency system that leaves no one behind."[82] The WARN Act stipulates that IPAWS must not rely on any one warning channel, must integrate existing warning methodologies, must utilize new technologies (such as cellular), must have geo-targeting capabilities for alerts, and

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[76] Bush, 1226.

[77] Post-Katrina Emergency Management Reform Act of 2006, Pub. L. 109-295 (2002), § 1394–1463, https://www.doi.gov/sites/doi.gov/files/uploads/Post_Katrina_Emergency_Management_Reform_Act_pdf.pdf.

[78] Post-Katrina Emergency Management Reform Act of 2006, 1408.

[79] Post-Katrina Emergency Management Reform Act of 2006, 1408–9.

[80] Warning, Alert, and Response Network Act, H.R. 5785, 109th Cong., 2nd Sess. (August 1, 2006), https://www.congress.gov/bill/109th-congress/house-bill/5785/text.

[81] H.R. 5785, the Warning, Alert, and Response Network Act of 2006: Hearing Before the Subcommittee on Telecommunications and the Internet of the Committee on Energy and Commerce House of Representatives, House of Representatives, 109th Cong., 2nd sess., July 20, 2006, 1, https://www.hsdl.org/?view&did=469686.

[82] U.S. Congress, House, 2.

must be available for use by all levels of government.[83] An overarching theme of the act is that the new system must alert as many Americans as possible.[84]

These policies of the U.S. government highlight the need for inclusive alerting for the American public. This history of warnings and alerts in the United States shows general improvement over time through enhanced technology and through the acknowledgement that warnings must also effectively serve those who have disabilities and other barriers. Despite these advancements, however, as recent events demonstrate, the reality of alerting still misses the mark of an ideal warning framework.

[83] U.S. Congress, House.

[84] U.S. Congress. House.

III. RESEARCH DESIGN

This thesis evaluates the ability of mobile alerting systems (Wireless Emergency Alerts and local mass notification systems), the Emergency Alert System (television and radio), and other technologies to effectively alert people who are deaf, blind, or experience other disabilities; people with limited English proficiency; and the elderly. Previous research shows that disasters impact such groups inordinately.[85] Additionally, related literature has a wealth of information pertaining to warning methodologies commonly used within the emergency management community in the United States for the general public. For example, Bean and his coauthors examine many of these warning methodologies, even though their focus is on mobile alerting.[86] The warning channels and systems reviewed for this thesis were chosen because they are generally available to emergency management at the local level, and local government is the first layer to respond in a disaster.

This thesis employed a qualitative methodology that involved reviewing and evaluating source material on how well warning systems have served those with functional and access needs. These sources are publicly available, and are generally government or scholarly publications. The design employed the value proposition framework and associated canvas as its method to review the current capabilities (the *haves*) against the requirements of the selected groups to identify where these systems fall short (the *needs*).[87] This is an appropriate review framework as it considers both the systems in question and the circumstances of the individuals they were designed to warn within the context of client experience.[88] The value proposition helped to generate recommendations, which are presented at the end of this thesis. Section B of this chapter provides a review of the value proposition process.

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[85] Deborah L. Witmer, "Dimensions of Public Engagement for Inclusive Emergency Planning" (master's thesis, Naval Postgraduate School, 2019), https://www.hsdl.org/?abstract&did=831033; National Council on Disability, *Effective Communications for People with Disabilities*.

[86] Bean, Mobile Technology; Bean et al., Comprehensive Testing.

[87] "The Value Proposition Canvas," Strategyzer, accessed February 19, 2020, https://www.strategyzer.com/canvas/value-proposition-canvas.

[88] Strategyzer.

A. CASE STUDIES SELECTED

To evaluate warning channels, this thesis also highlights five case studies. The first three case studies—the Oroville Dam evacuation in 2017, wildfires in the western United States between 2017 and 2018, and Hurricane Harvey in 2017—are relatively recent and illustrate how current warnings and notifications systems affected the outcomes of disasters in numerous ways. For these cases, the thesis fleshes out specific information about alerting the referenced groups, such as whether or not warnings were sent, received, and appropriately acted upon. These findings generate information to populate the value proposition canvas, including gaps and potential solutions. The value proposition canvas, which is described in Section B, is used as a method to tailor solutions to the warning requirements of people with functional and access needs based on the case studies.

Two additional case studies—which focus on Canada's and New Zealand's alerting systems—are integrated to pose possible solutions. These countries were selected because they are English-speaking and because their alerting channels illustrate how others have overcome similar challenges. For the case studies, this thesis specifically reviews national warning methodology and accessibility practices. The findings of these case studies informed the value proposition canvas.

B. VALUE PROPOSITION FRAMEWORK

The objective of this thesis is to identify ways to warn people with functional and access needs more effectively in emergencies and disasters. The value proposition, developed by Alexander Osterwalder et al. and described in more detail below, is an apt framework for reviewing possible solutions.[89] One of the advantages to the value proposition is that it heavily considers the perspective of the customers, or those who would potentially use a good or service. For this thesis, the customers are people who have functional or access needs and the service is emergency warning.

[89] Osterwalder et al., Value Proposition Design.

Value proposition, according to Osterwalder et al., "describes the benefits customers can expect from . . . products and services."[90] But how does this methodology reveal the perspective of the customer relative to a product or service? Two of the main tools the value proposition uses to identify the perspective of the customer are the value proposition map and the customer profile. The former defines the goods and services in question and in what ways they bring worth to the table by naming problems they overcome and how they seek to aid the target audience.[91] The latter comprises an analysis of the desired objectives, potential stumbling blocks, and exertions of the target audience.[92] When the two combine, the result is the value proposition canvas, shown in Figure 2, which dovetails the product or services with the desires of the customer.[93]

The methodology is best described by Osterwalder et al.: "With the Customer Profile . . . you clarify your customer understanding. With the Value Map . . . you describe how you intend to create value for that customer. You achieve Fit . . . between the two when one meets the other."[94] The idea of looking specifically at the needs of the customers, or individuals receiving alerts and warnings, is important for the often overlooked population of people with functional and access needs. As June Kailes and Alexandra Enders relay, "Typically, disaster preparedness and emergency response systems are designed for people for whom escape or rescue involves walking, running, driving, seeing, hearing, and quickly responding to directions."[95] Thus, the value proposition can help integrate the requirements of these end users. Understanding these demographic requirements is important for emergency managers who want to ensure that warning systems are as inclusive as possible. This thesis uses the value proposition to guide practitioners in their efforts to effectively warn all segments of their constituencies

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[90] Osterwalder et al., 6.

[91] Osterwalder et al., 8.

[92] Osterwalder et al., 9.

[93] Osterwalder et al., 3.

[94] Osterwalder et al., 3.

[95] June Isaacson Kailes and Alexandra Enders, "Moving Beyond 'Special Needs': A Function-Based Framework for Emergency Management and Planning," *Journal of Disability Policy Studies* 17, no. 4 (2007): 235, https://doi.org/10.1177/10442073070170040601.

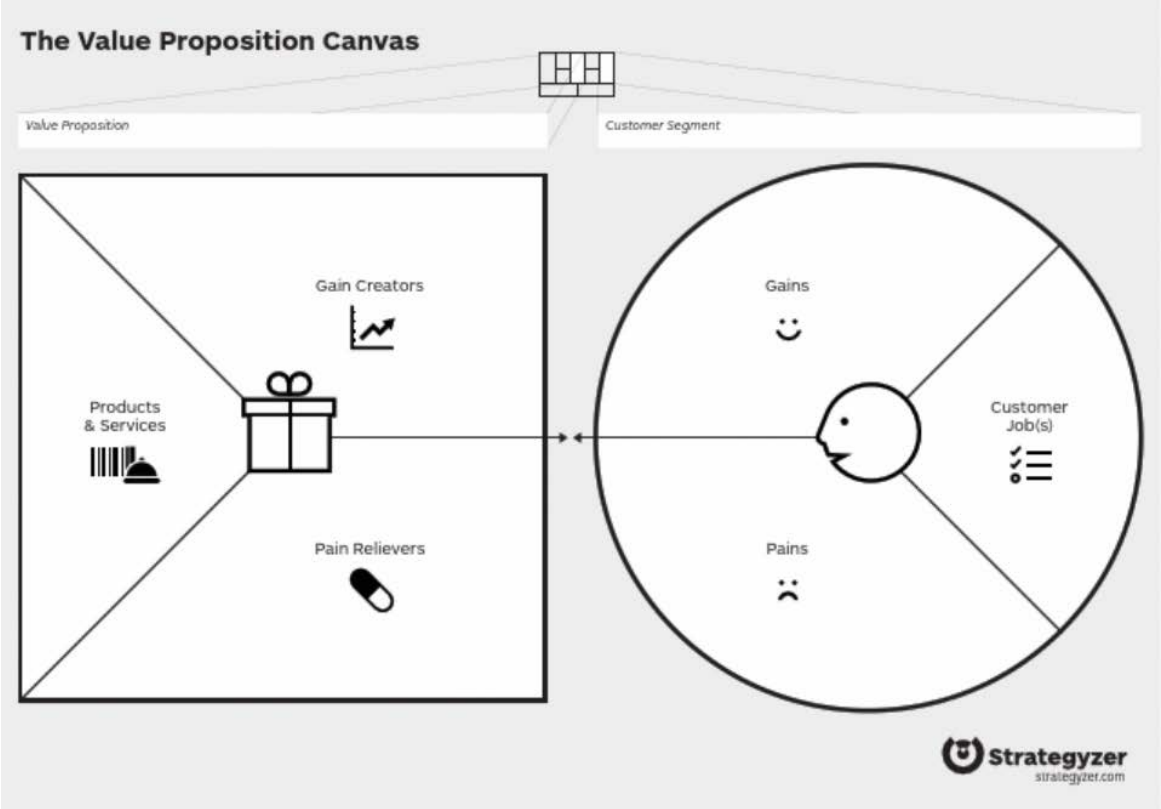

Figure 2. The Value Proposition Canvas[96]

96 Source: Osterwalder et al., 61.

IV. U.S. CASES IN INCLUSIVE ALERTING: IDENTIFYING GAPS

While the 2017 Oroville Dam incident and subsequent evacuations received national attention, the incident was joined that year by numerous devastating hurricanes and wildfires, some of which this thesis details later. These nearly concurrent incidents deserve careful analysis, as they contain valuable lessons for the future, including lessons about public warnings. In addition to the Oroville incident, this chapter focuses on the 2017 and 2018 California wildfires and Hurricane Harvey, and draws conclusions about where government warnings fell short for those most vulnerable.

A. OROVILLE DAM INCIDENT

During the Oroville Dam incident, government organizations had to issue evacuations for a wide variety of persons, some of whom were elderly or were experiencing disabilities. When government entities disseminate warnings and other communications to such a large cross-section of the public, other alert originators should take note of their practices, to include reviewing them as case studies.

At over three million acre-feet, the reservoir at Oroville, situated along the Feather River in northern California, is the second largest non-natural lake in the state.[97] The reservoir also has recreational features, as there is a nearby boat ramp and a scenic overlook.[98] Oroville Dam is a feat of engineering. According to the city of Yuba City, California, "At 770 feet high, it is the tallest dam in the U.S. and serves mainly for water supply, hydroelectricity generation and flood control."[99] The threat posed from a failure at this structure was dire due to the downstream consequences of an uncontrolled release of water.

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97 City of Yuba City, Yuba City Fire Department, and Yuba City Police Department, *Post Incident Action Summary: Flood Watch 2017* (Yuba City, CA: City of Yuba City, 2017), 5, https://www.yubacity.net/common/pages/DisplayFile.aspx?itemId=8089935.

98 "Lake Oroville Spillway Incident: Timeline of Major Events February 4–25," State of California Department of Water Resources, February 21, 2017, 2, https://www.palmdalewater.org/wp-content/uploads/2017/04/Item5.1.pdf.

99 City of Yuba City, Yuba City Fire Department, and Yuba City Police Department, *Post Incident Action Summary*, 5.

In February 2017, the area experienced a tremendous amount of precipitation.[100] The ensuing issue at the dam was a veritable one-two punch. Agency personnel from California's Department of Water Resources noted an irregularity at one of the spillways at the dam (not the dam itself) on February 7, 2017.[101] Officials detected damage to the concrete after stopping the outflow of water through this spillway for inspection.[102] Over the next several days, while this spillway was shut off for continued work, the level of the reservoir continued to rise due to rainfall and incoming water from upstream.[103] As a result, the other (emergency) spillway had its first real-world use on February 11.[104] However, this spillway, too, developed an alarming issue. While officials had predicted that the hillside below the emergency spillway would wear away to some extent, they had not expected the rapid rate at which this process degraded the hillside.[105] When they noticed this situation, on February 12, local law enforcement issued an evacuation order for the downstream area.[106] Despite the concern over the spillways and the evacuations (for which orders lasted a few days), the reservoir level eventually subsided and the emergency spillway no longer had water flowing over it, which enabled dam personnel to assess damage.[107] See figures 3 and 4 for a map of the incident area and an overview of Oroville Dam.

[100] City of Yuba City, Yuba City Fire Department, and Yuba City Police Department, 5; Department of Homeland Security Analytic Exchange Program, *Communication Tools to Increase Communities' Resilience* (Washington, DC: Department of Homeland Security, 2017), 6, https://www.hsdl.org/?view&did=826437.

[101] State of California Department of Water Resources, "Lake Oroville Spillway Incident," 1.

[102] State of California Department of Water Resources, 1.

[103] State of California Department of Water Resources, 1.

[104] State of California Department of Water Resources, 1.

[105] State of California Department of Water Resources, 1.

[106] State of California Department of Water Resources, 1.

[107] State of California Department of Water Resources, 1.

Figure 3. Map of Area Surrounding Oroville Dam[108]

108 Source: Madison Park and Eliott C. McLaughlin, "Evacuations Ordered over Concerns at California Dam System," CNN, February 13, 2017, https://www.cnn.com/2017/02/12/us/california-oroville-dam-failure/index.html.

Figure 4. Oroville Dam Overview[109]

1. Incident Alerts

The Oroville Dam incident involved a massive response effort. First, the incident ultimately resulted in mandates for approximately 200,000 persons to evacuate.[110] The Department of Homeland Security study describes the Oroville Dam incident as "the largest 'peacetime' non-hurricane related evacuation in U.S. history."[111] Second, the incident onset time was rapid: only sixty minutes elapsed between the initial public dissemination of emergency notifications and the potential dam failure.[112] There are three key communication and warning takeaways from this incident. First, given the timeframe of the incident and warnings, people with functional and access needs benefit from more forewarning of pending threats. Second, public outreach and education efforts are important for warning efficacy among people with disabilities, the elderly, or people with

[109] Source: State of California Department of Water Resources, "Lake Oroville Spillway Incident," 2.

[110] Department of Homeland Security Analytic Exchange Program, *Communication Tools*, 3.

[111] Department of Homeland Security Analytic Exchange Program, 9.

[112] City of Yuba City, Yuba City Fire Department, and Yuba City Police Department, *Post Incident Action Summary*, 2; Department of Homeland Security Analytic Exchange Program, *Communication Tools*, 10.

limited or no ability to communicate in English. Third, alert originators should use more varied means for alerting their constituents.

a. Early Warnings

The timeframe of the Oroville incident presented challenges for evacuation. For example, as revealed at a joint Sutter and Yuba Counties public feedback session following the incident, the evacuation orders took residents by surprise, as they had received little information about the worsening conditions at the Dam before the orders.[113] Due to the rapid progression of the incident and the very short time between the first public warnings and the potential spillway failure, the people in harm's way had to act very quickly (see Figure 5). However, as many residents at the public feedback session discussed, there was a great deal of confusion surrounding the evacuation. Several residents referenced that the public did not have the information they needed, when they needed it.[114] One man argued at the forum that the forewarning to the public could have happened much earlier, allowing for more time to evacuate; while hiking near the dam, he claimed that Department of Water Resources personnel had told him the dam was in danger and that he should leave immediately, and he cited a ninety-minute warning delay thereafter.[115]

[113] "Oroville Dam Spillway Evacuation Feedback Session," Sutter County, California, March 16, 2017, https://www.suttercounty.org/doc/government/depts/cao/em/stormupdate.

[114] Sutter County, California.

[115] Sutter County, California.

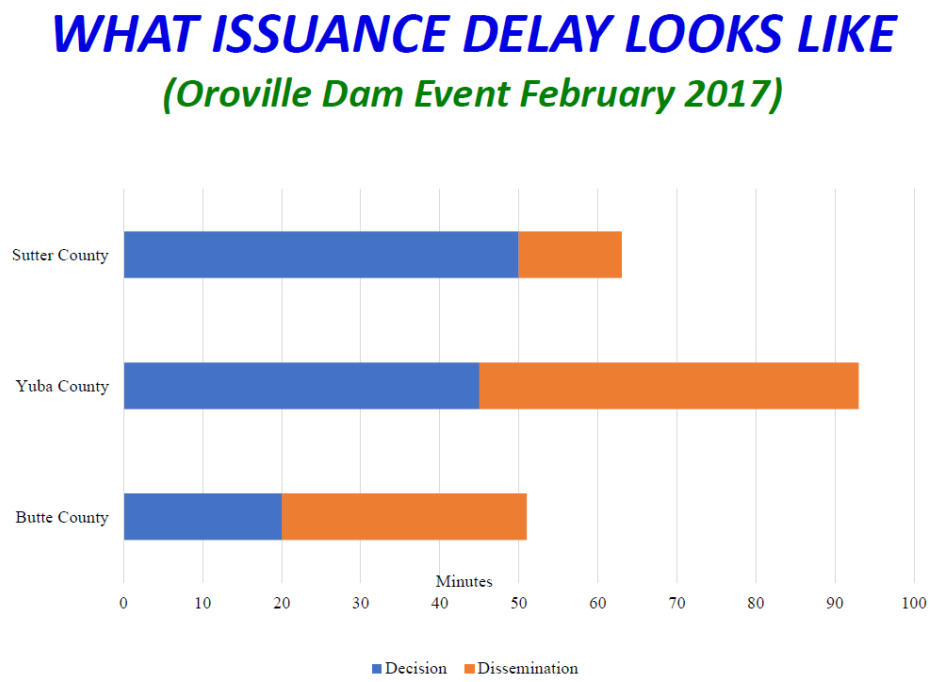

Figure 5. Oroville Dam Incident Warning Timelines[116]

While short lead times can prove challenging for the general public, they are even more problematic for those with functional and access needs. As shown in Figure 5, indecisiveness and overall delays in warnings can become problematic, especially when the potential for a catastrophic spillway failure could occur in roughly one hour. Indeed, Mileti mentions that in incidents such as Oroville, effective warnings and notifications can prove extremely beneficial for positive disaster outcomes, especially when warnings are redundant, expeditiously sent, and crafted and planned well.[117] In the joint Sutter and Yuba County public response meeting, there were several references to evacuation difficulties for people with functional and access needs.[118] One woman with vision loss said she stayed

[116] Source: Dennis S. Mileti, "Modernizing Public Warning Messaging" (paper presented at the National Tsunami Hazard Mitigation Program [NTHMP] Annual Meeting, San Diego, CA, January 30, 2019), 19, https://nws.weather.gov/nthmp/2019annualmeeting/Mileti.pdf.

[117] Mileti, 12–32.

[118] Sutter County, California, "Oroville Dam Spillway Evacuation Feedback Session."

with a friend during the incident and that they were both unable to leave; another woman had to return to her home in an evacuation zone due to a lack of accessibility at a shelter.[119]

The speed at which the incident at Oroville progressed is particularly troubling. As the National Council on Disability contends, "there are significant concerns about rapid onset events, especially for people with disabilities, who may require additional time to shelter in place or evacuate to a safer location."[120] Mileti, the National Council on Disability, and the lessons of the Oroville incident all underscore the importance of timely warnings and notifications, particularly for people with functional and access needs.

b. Public Education, Outreach, and Planning

Another takeaway from the Oroville incident is the importance of public outreach and education within the context of warnings. This is especially true for those with functional and access needs, as the National Council on Disabilities has argued.[121] During the joint Sutter and Yuba County public response meeting, the public speakers in attendance raised concerns about warning sirens, the timeframe of warnings, and access to technology to receive vital information.[122] For example, one gentleman complained that there were not enough warnings and that alerts should have been more expeditious; with more forewarning, he said, he could have assisted a friend experiencing vision loss.[123] While another man appreciated the information flow from an elected official's office later in the incident, he believed that there should have been more of it.[124] While the city's local mass notification system was used promptly during the incident, officials needed to promote its use with the public.[125].

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[119] Sutter County, California.

[120] National Council on Disability, *Effective Emergency Management: Making Improvements for Communities and People with Disabilities* (Washington, DC: National Council on Disability, 2009), 39, https://www.ncd.gov/rawmedia_repository/50b76caf_054c_491d_ae88_587c096d8b3a.pdf.

[121] National Council on Disability, 95.

[122] Sutter County, California, "Oroville Dam Spillway Evacuation Feedback Session."

[123] Sutter County, California.

[124] Sutter County, California.

[125] City of Yuba City, Yuba City Fire Department, and Yuba City Police Department, *Post Incident Action Summary*, 3.

The Department of Homeland Security study, too, underscores the point that, for people with functional and access needs, public trust "also affects the willingness of vulnerable community members to share information about themselves. . . . Emergency managers found that their participation in community engagement activities (including formal information sessions . . .) created public trust and buy-in for these efforts."[126] Thus, public education and outreach are of vital importance, especially for those with potential barriers to receiving warnings and notifications.

c. Varying Means

The final takeaway from the Oroville incident is that alert originators should use as many means to warn the public as possible, as individuals may have different needs or preferences. This idea is supported by the joint Sutter and Yuba County public response meeting, during which residents mention a wide variety of warning and notification systems, including sirens, phone-based systems, and television and radio.[127] When the comments by the public are taken in aggregate, they generally support all of these systems being used more, and in tandem.[128]

The academic literature supports this concept. Mileti strongly suggests that, rather than relying on one warning system, alert originators should use a wide variety of systems.[129] While weaknesses and strengths are inherent in each system, this strategy, Mileti posits, can help meet the needs of people who have disabilities, who are away from home, who have limited proficiency in English, and others.[130] The Department of Homeland Security came to the same conclusions, suggesting that different individuals, including those with disabilities, may be better served by different systems; therefore, numerous systems should be used to ensure effective warnings.[131]

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[126] Department of Homeland Security Analytic Exchange Program, *Communication Tools,* 20.

[127] Sutter County, California, "Oroville Dam Spillway Evacuation Feedback Session."

[128] Sutter County, California.

[129] Mileti, "Modernizing Public Warning Messaging," 21–28.

[130] Mileti, 21, 28.

[131] Department of Homeland Security Analytic Exchange Program, *Communication Tools,* 26–44.

2. Conclusion

While thankfully the Oroville Dam spillway remained intact and there was no inundation of downstream areas, the incident still involved a massive evacuation effort.[132] This enormous undertaking suggests that expeditious warnings and notifications are of vital importance to people with functional and access needs, that public warning outreach and education are similarly important, especially for those with disabilities or other access barriers, and that government agencies should not rely on one system.

B. 2017 AND 2018 CALIFORNIA WILDFIRES

In recent years, wildfires in the United States have been particularly challenging for public safety agencies and residents of impacted areas. The number of government jurisdictions involved, the rapid timeframe of incident onset, impacted infrastructure, and depletion of resources have been exacerbating factors during the response to these noteworthy conflagrations. The strain on public safety entities has been immense.

The Tubbs Fire occurred in the California counties of Napa and Sonoma in autumn 2017; while the Tubbs Fire was part of a group of concurrent fires dubbed the Complex Fires, Tubbs covered the most territory.[133] The Tubbs fire killed 22 people and destroyed 5,636 buildings.[134] Additionally, the affected land area was estimated at over 110,000 acres.[135] The Sonoma County after-action report for the Complex Fires highlights that previous fire incidents had moved at a far slower pace.[136] The reported further stated, "The scope, scale, and duration of the wildfires pushed the County's Emergency

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[132] Sutter County, California, "Oroville Dam Spillway Evacuation Feedback Session."

[133] County of Sonoma, *October 2017 Complex Fires: Emergency Operations Center After Action Report & Improvement Plan* (Santa Rosa, CA: County of Sonoma, 2018), 5, https://sonomacounty.ca.gov/WorkArea/DownloadAsset.aspx?id=2147560486; Office of the Auditor of the State of California, *California Is Not Adequately Prepared to Protect Its Most Vulnerable Residents from Natural Disasters*, Emergency Planning Report 2019-103 (Sacramento, CA: Office of the Auditor of the State of California, 2019), 12, https://www.auditor.ca.gov/reports/2019-103/chapters.html.

[134] David Hawks, "Camp Fire - November 8, 2018" (paper presented at the 5th Annual Conference - Nevada Division of Forestry, Reno NV, April 22, 2019), http://forestry.nv.gov/wp-content/uploads/2019/05/Camp-Fire-Presentation-Fire-Adapted-Nevada-Final.pdf.

[135] County of Sonoma, October 2017 Complex Fires, 6.

[136] County of Sonoma, 9.

Operations Center (EOC) facility, systems, and staff well beyond their design limits and experience. Some 660 EOC staff provided over 33,000 hours of service during 47 days of activation."[137]

Additionally, two noteworthy California fires in 2018 were the Woolsey and Camp Fire incidents, which happened concurrently in autumn.[138] The Woolsey Fire annihilated 1,643 buildings and impacted an area in Los Angeles and Ventura Counties of 96,949 acres.[139] The Camp Fire eliminated nearly 19,000 buildings and charred more than 83,000 acres.[140] However, there is one notable difference between these fires—the human toll. Whereas the Woolsey Fire killed three people, the Camp Fire resulted in eighty-five deaths.[141] All three of these fires presented challenges within the alerting arena, especially for people with functional and access needs.

1. Incident Alerts

According to the Office of the Auditor of the State of California, the wildfires had an outsized effect on seniors and impacted others with functional and access needs; Table 2 shows fatality data for this group.[142] As with the Oroville Dam incident, these fires offer communication and warning takeaways. First, public and alert originator education and planning are vital. And second, alert originators should not rely on too few channels to warn the public, and must use—and maintain—the systems available to them.

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[137] County of Sonoma, 1.

[138] Citygate Project Team, *After Action Review of the Woolsey Fire Incident: County of Los Angeles* (Los Angeles: County of Los Angeles, 2019), 2, https://lacounty.gov/recovery/report/; Hawks, "Camp Fire."

[139] Citygate Project Team, After Action Review of the Woolsey Fire Incident, 4.

[140] Hawks, "Camp Fire."

[141] Citygate Project Team, *After Action Review of the Woolsey Fire Incident*, 1; Hawks, "Camp Fire."

[142] Office of the Auditor of the State of California, *California Is Not Adequately Prepared*, 13.

Table 2. Wildfire Fatality Demographic Information[143]

COUNTY	FATALITIES	FATALITIES 65 YEARS OF AGE OR OLDER	FATALITIES WHERE THE CORONER RECORDS NOTED A POTENTIAL ACCESS OR FUNCTIONAL NEED*
Butte	85†	67	13
Sonoma	24	18	7
Ventura	5	3	0

a. Public Education, Outreach, and Planning

According to a recent NEMA wildfire emergency management workshop summary, wildfire notifications are not as well developed as those for other hazards, such as for severe weather, even though wildfires are increasing in magnitude and frequency.[144] Education for and planning with the public for these events is important. Indeed, the Office of the Auditor observes that, during the California wildfires, several local governments "sent messages through notification systems that reach landlines and reach a person's cell phone only if that person has preregistered to receive emergency alerts from the county."[145] Public coordination and outreach must happen before an emergency to encourage registration with such mass notification systems. Additionally, various local alert originators have different authorization procedures, inconsistent alert language, different software programs, insufficient confidence in Wireless Emergency Alert technology, and varying capabilities, and there is little collaboration among such entities.[146] Based on the 2018 wildfire season, NEMA identified a dearth of consistent standards as an issue within wildfire alerting, and identified a need for teaching alert

[143] Source: Office of the Auditor of the State of California, 13.

[144] National Emergency Management Association, "Wildfire Alert & Notification Workshop."

[145] Office of the Auditor of the State of California, *California Is Not Adequately Prepared*, 2.

[146] National Emergency Management Association, "Wildfire Alert & Notification Workshop."

originators how to use Integrated Public Alert and Warning System.[147] These issues point to a need for increased education and planning for, by, and between alert originators.

After the Complex Fires, Sonoma County also identified shortfalls in alerting persons with access needs. As the county explains, local law enforcement used a mass-notification system in several instances.[148] However, the county noted the need to incorporate Spanish-language emergency messaging and to "work with the Access and Functional Needs (AFN) Advisory Group to develop messaging, communications, and services that fully address the requirements of the whole community."[149] After the Woolsey Fire, Los Angeles County also found that alerting authority personnel lacked procedures for and education on the local mass-notification system, and a hesitance to use Wireless Emergency Alerts due to fears of over-alerting regions not impacted by the fire.[150]

Overall, the Office of the Auditor concluded that California counties had not planned sufficiently to warn the public about the wildfires.[151] Public safety agencies did not fully appreciate or research the social makeup of their jurisdictions, which led to ineffectual planning, particularly for vulnerable populations; the auditor's report mentions the need to work with community partners and for the State of California to bolster local efforts and to follow state statutory mandates.[152] These examples underscore the importance of planning and education for public safety agencies.

b. Varying Systems

Relying on too few systems may mean only a small fraction of the population can benefit from warnings. During the Woolsey Fire, response personnel put too much faith in Twitter's ability to successfully warn the public, and underused actual warning systems,

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147 National Emergency Management Association.

148 County of Sonoma, *October 2017 Complex Fires*, 5–7.

149 County of Sonoma, 22.

150 Citygate Project Team, After Action Review of the Woolsey Fire Incident, 87.

151 Office of the Auditor of the State of California, *California Is Not Adequately Prepared*, 18.

152 Office of the Auditor of the State of California, 19–21, 23–27, 3.

including Wireless Emergency Alerts, local mass-notifications, and the Emergency Alert System—including mobile alerts, though many sources note that mobile alerting is not perfect.[153] When discussing the counties' challenges for reaching vulnerable populations, the Office of the Auditor states, "Despite having access to [Wireless Emergency Alerts] that could reach all cell phones in their evacuation zones, Butte and Sonoma did not send alerts using that technology."[154] It is worth noting, however, that not all cellphones in a given area are compatible with such systems, and that cellular towers had been damaged by wildfires on numerous occasions, which hampered the ability to send Wireless Emergency Alerts; the county of Los Angeles recognizes that they failed to account for how infrastructure disruptions could detrimentally impact emergency notifications during the Woolsey Fire.[155] The Office of the Auditor recommends the use of multiple warning systems, in part, to circumvent potential damages to communications systems.[156] While most coverage about the Wireless Emergency Alerts systems has been about its underuse, a *New York Times* article from late 2017 references a Wireless Emergency Alert the state of California sent to numerous counties warning of hazardous fire conditions.[157]

Butte County compiled a series of lessons-learned videos for the Camp Fire incident, and one highlights how people with access and functional needs are vulnerable in disasters.[158] The video makes mention of how mass notification calls only reached a fraction of the persons impacted in the county.[159] One of the other videos describes how

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153 Citygate Project Team, *After Action Review of the Woolsey Fire Incident*, 86; National Emergency Management Association, "Wildfire Alert & Notification Workshop."

154 Office of the Auditor of the State of California, *California Is Not Adequately Prepared*, 2.

155 Citygate Project Team, After Action Review of the Woolsey Fire Incident, 86.

156 Office of the Auditor of the State of California, *California Is Not Adequately Prepared*, 28.

157 Richard Pérez-Peña, "Fire Alert Sent to Millions of Cellphones Was California's Largest Warning Yet," *New York Times*, December 7, 2017, https://www.nytimes.com/2017/12/07/us/cellphone-alerts-california-fires.html.

158 Christopher Allen Smith, "Part 2: Day of Fire - Camp Fire Lessons Learned," YouTube video, November 18, 2019, 16:57, https://www.youtube.com/watch?v=vl_qM1HTRHk.

159 Smith.

emergency notifications were hampered by cellular infrastructure damage from the fire.[160] The themes generally parallel the other fires.

This public discussion did not go unnoticed by California's state legislature, and efforts to implement changes are in the works. According to a California state senator, in early 2020, the California legislature initiated an effort to address the gaps in alerting highlighted by the fires and the previously referenced audit.[161] This effort was represented by Senate Bill 794.[162] As of June, 2020, the bill had passed in the California State Senate and was referred to committee within the California State Assembly.[163] The bill, in its May 26, 2020, iteration, contains several revisions to California State statutes. It would permit local government to take steps to improve warnings and notifications for constituents with functional and access needs and would require certain emergency planning functions. Generally, local mass notifications systems require users to register and input their own data into the system in order to receive warnings. Phone listings for landline telephones may be automatically integrated, though this technology has seen diminished use. The bill would permit local public safety officials, in certain circumstances, to use phone numbers and similar personal data from other government databases to register vulnerable people, or their caretakers, for local mass-notification systems.[164] However, the persons affected must be notified if this registration occurs and have the ability to remove their information from the local mass-notification system.[165] Additionally, this bill would require integration

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[160] Christopher Allen Smith, "Part 4: Lessons Learned - Camp Fire Lessons Learned," YouTube video, November 18, 2019, 16:43, https://www.youtube.com/watch?v=K4dIjn6B9b4.

[161] "Following State Audit, Jackson Introduces Bill to Improve Emergency Alerts for Vulnerable Residents and Students," Hannah-Beth Jackson Representing Senate District 19, January 7, 2020, https://sd19.senate.ca.gov/news/2020-01-07-following-state-audit-jackson-introduces-bill-improve-emergency-alerts-vulnerable.

[162] "SB-794 Emergency Services: Telecommunications," California Legislative Information, July 21, 2020, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201920200SB794.

[163] "SB-794 Emergency Services: Telecommunications - Bill History," California Legislative Information, August 3, 2020, http://leginfo.legislature.ca.gov/faces/billHistoryClient.xhtml?bill_id=201920200SB794.

[164] "SB-794 Emergency Services: Telecommunications - Today's Law as Amended," California Legislative Information, accessed June 21, 2020, http://leginfo.legislature.ca.gov/faces/billCompareClient.xhtml?bill_id=201920200SB794&showamends=false#.

[165] California Legislative Information.

of vulnerable populations into the local emergency planning process.[166] The bill would give local public safety agencies access to cellphone numbers (if available) from other government sources, thus eliminating the need for users to self-register.

Another state response following the 2017 and 2018 wildfire seasons was a warning and notifications guidelines document published by the California Governor's Office of Emergency Services in March 2019.[167] One of the overarching purposes of the document was to make emergency warnings more uniform throughout California.[168] The guidelines have integrated many planning practices on the warning of vulnerable populations. While time will tell how effective California's efforts will be to solve warning shortfalls, these efforts represent those of only one state out of fifty in the United States. If these efforts are successful, they may be able to serve as a guide for alerting authorities in other regions.

2. Conclusion

The California wildfires of 2017 and 2018 were particularly challenging, for local public safety agencies and the public alike. The rapid expansion of the fires and large areas impacted, along with concurrent, multijurisdictional responses and communications disruptions, proved particularly challenging for responders. These challenges also extended into the realm of public warnings and notifications. There are numerous key observations from the fires: public and alert originator education and planning are vital; alert originators should not rely on too few channels to warn the public; the Wireless Emergency Alerts system is underused; and damaged warning infrastructure will hamper efforts to warn the public.

Data about incident-related fatalities suggest that the elderly and other vulnerable populations suffered in a disproportionate manner.[169] While it is impossible to know the exact extent to which timely warnings and notifications through redundant channels could

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166 California Legislative Information..

167 State of California, *State of California Alert & Warning Guidelines* (Sacramento: California Governor's Office of Emergency Services, 2019), http://calalerts.org/documents/2019-CA-Alert-Warning-Guidelines.pdf.

168 State of California, 7.

169 Office of the Auditor of the State of California, *California Is Not Adequately Prepared*, 13.

have improved incident outcomes for people with access and functional needs, the literature highlights this area as a shortfall for incident response during the 2017 and 2018 wildfires.

C. HURRICANE HARVEY

The hurricanes of 2017 proved to be particularly challenging for all levels of government, and for the public within the paths of the storms. According to the Federal Emergency Management Agency's after-action report for that hurricane season, "Hurricanes Harvey, Irma, and Maria caused a combined $265 billion in damage and resulted in widespread displacement of survivors."[170] Hurricane Ike was the last hurricane before Harvey to slam Texas, and it made landfall nearly nine years earlier.[171] Harvey attained tropical storm status on August, 17, 2017, having formed a few days earlier near Africa.[172] Harvey moved generally westward, through the Caribbean, gaining strength.[173] A Category 4 storm by the time it crashed into Texas, Harvey brought incredible damage during the evening of August 25.[174] Exacerbating the situation, the storm stalled its advance and the rainfall caused incredible flash flooding around Houston.[175] Hurricane Harvey ultimately killed 103 persons in the United States, through primary or secondary means, and caused $125 billion in damage.[176] Furthermore, Galveston and Harris Counties received a tremendous amount of rainfall.[177] Not surprisingly, the primary impacts for

170 Federal Emergency Management Agency, *2017 Hurricane Season FEMA After-Action Report* (Washington, DC: Department of Homeland Security, 2018), v, https://www.hsdl.org/?abstract&did=812985.

171 "Hurricane Harvey Info," National Weather Service, accessed May 23, 2020, https://www.weather.gov/hgx/hurricaneharvey.

172 National Weather Service.

173 National Weather Service.

174 National Weather Service.

175 National Weather Service.

176 Federal Emergency Management Agency, *2017 Hurricane Season*, 1.

177 National Weather Service, "Hurricane Harvey Info."

Harrison County (where Houston is located) were related to flooding.[178] The National Weather Service also recorded numerous wind gusts in excess of 100 miles per hour near Rockport (northeast of Corpus Christi and southwest of Houston); see Figure 6.[179]

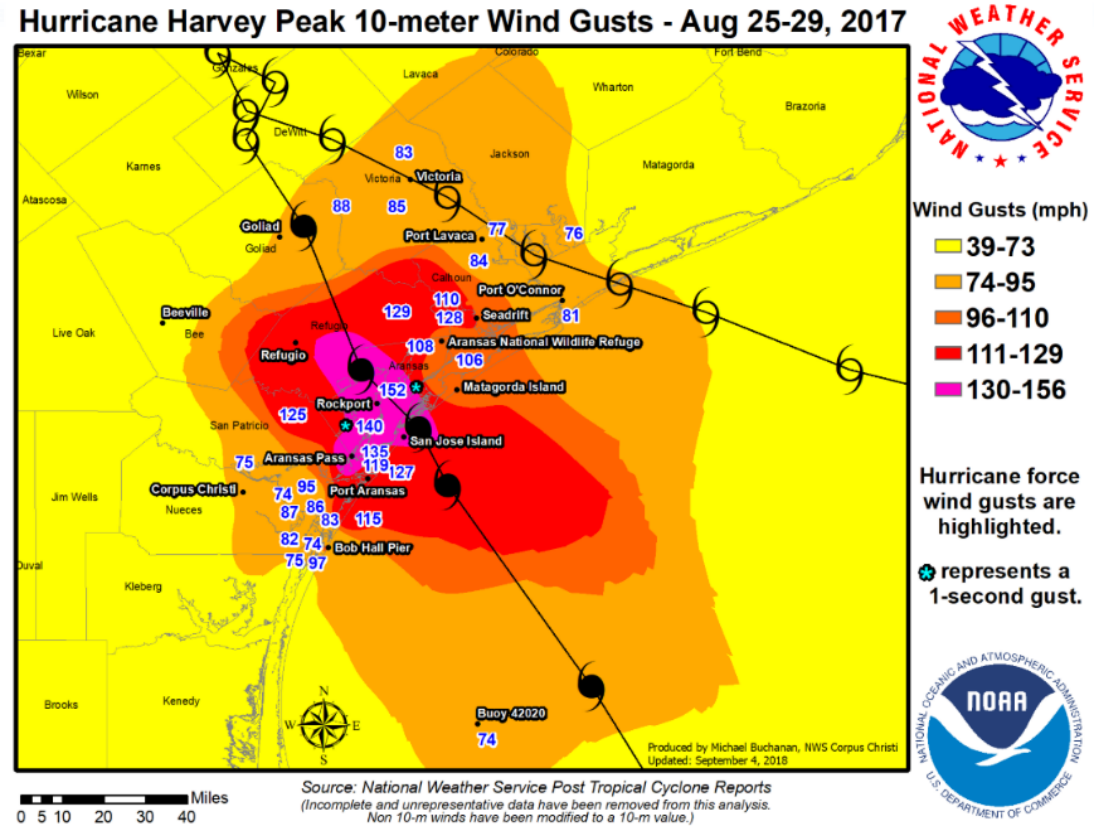

Figure 6. Hurricane Harvey Wind Gusts[180]

178 Harris County Office of Homeland Security and Emergency Management, *Hurricane Harvey After Action Report* (Houston, TX: Harris County Office of Homeland Security & Emergency Management, 2018), 3, https://www.readyharris.org/Portals/43/PDFs/Hurricane%20Harvery%20AAR_Final.pdf?ver=2018-05-14-144548-187.

179 "Major Hurricane Harvey - August 25–29, 2017," National Weather Service, accessed June 23, 2020, https://www.weather.gov/crp/hurricane_harvey.

180 Source: National Weather Service.

Even in an extremely eventful year for disasters in the United States, Hurricane Harvey stood out due to its major impacts in a very populous part of the country. According to the National Hurricane Center, prior to the storm's impact, the organization (as part of the National Weather Service) issued an ominous bulletin on August 24, which stated in part, "HARVEY HEADED TOWARD THE TEXAS COAST . . . LIFE-THREATENING AND DEVASTATING FLOODING EXPECTED NEAR THE COAST DUE TO HEAVY RAINFALL AND STORM SURGE."[181] At that time, numerous watches and warnings were already in place; yet the impacts were still devastating.[182]

1. Incident Alerts

There are several takeaways from Hurricane Harvey. First, research suggests that residents with functional and access needs were impacted disproportionately by flooding from Harvey.[183] Emergency management must therefore better incorporate this population into emergency planning and the public education process. The literature also suggests timely warnings could have been hampered by overwhelmed or damaged infrastructure. And finally, the incident underscores that warning systems should be improved to better serve those with functional and access needs and that resilient, alternative technologies are vital.

a. Public Education, Outreach, and Planning

Individuals with disabilities lived in greater concentrations in the most flood-impacted areas around Houston during Hurricane Harvey.[184] While there is previous disaster research for other populations, there is little literature that focuses on people with functional and access needs.[185] In an article titled "Hurricane Harvey and People with

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[181] "Hurricane Harvey," National Hurricane Center and Central Pacific Hurricane Center, August 24, 2017, https://www.nhc.noaa.gov/archive/2017/al09/al092017.public.018.shtml?.

[182] National Hurricane Center and Central Pacific Hurricane Center.

[183] Jayajit Chakraborty, Sara E. Grineski, and Timothy W. Collins, "Hurricane Harvey and People with Disabilities: Disproportionate Exposure to Flooding in Houston, Texas," *Social Science & Medicine* 226 (April 2019): 176, https://doi.org/10.1016/j.socscimed.2019.02.039.

[184] Chakraborty, Grineski, and Collins.

[185] Chakraborty, Grineski, and Collins, 176.

Disabilities," however, the authors highlight this gap.[186] As they conclude: "Statistical findings indicate that the overall proportion of civilian noninstitutionalized persons with a disability is significantly greater in neighborhoods with higher proportions of flooded area. . . "[187] Thus, within the context of Harvey, warnings and notifications for those with disabilities were even more important; as this research suggests, they may have been more susceptible to flooding.

The incident demonstrates the need for increased coordination, planning, and education between emergency management and people with functional and access needs. The Texas Disability Task Force on Emergency Management published an after-action report for Hurricane Harvey that specifically addresses functional and access needs issues during and after the storm.[188] The task force broke recommendations down into numerous categories, including communication.[189] One recommendation states, "A meeting should be held specific to issues related to accessible emergency telecommunications in the context of alerts, warnings, notifications, and response to disasters."[190] While the task force does not elaborate more on the issue, this recommendation shows that more work is required. The task force goes on to recommend that the Texas Division of Emergency Management should create a new functional and access needs liaison to bolster the lines of communication between public safety and functional and access needs organizations.[191] Furthermore, it makes several recommendations to improve coordination, planning, and education between local emergency management and disability communities.[192] The overarching theme is to bolster relationships, share information, and engage in pre-planning between the aforementioned groups for improved outcomes for people with functional and access needs in future disasters.

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[186] Chakraborty, Grineski, and Collins, 177.

[187] Chakraborty, Grineski, and Collins, 179.

[188] Texas Disability Task Force on Emergency Management, *Hurricane Harvey After Action Report on Individuals with Disabilities* (Austin: Texas Division of Emergency Management, 2019).

[189] Texas Disability Task Force on Emergency Management, 3.

[190] Texas Disability Task Force on Emergency Management, 3.

[191] Texas Disability Task Force on Emergency Management, 4.

[192] Texas Disability Task Force on Emergency Management, 4.

b. Early Warnings

Timeliness of warnings is another concern. Area 9-1-1 centers experienced greatly increased call volume during Hurricane Harvey.[193] This situation, when coupled with infrastructure damaged described below, could easily lead to delayed alerts or an inability to send them; as Mileti has highlighted, the timeliness of alerts is vital in ensuring they are effectual.[194] Such delays have detrimental impacts on the broader public, and especially those with functional and access needs, as the latter could take longer to react after receiving an alert.[195]

c. Varying Means

Another aspect illuminated by Harvey is the need for accessibility updates to Wireless Emergency Alerts. While upgrades to this system were stressed even before Harvey, Emergency Manager Francisco Sánchez explains that the system should be able to send alerts in languages other than English and should be able to include audio, graphical, and video components.[196] Sánchez goes on to reference how these capabilities, if added to the system, would benefit those with functional and access needs.[197] "Had multimedia capabilities been available for WEA messages [during Hurricane Harvey]," he writes, "inundation maps, traffic maps and infographics with protective measures could have been sent to residents, alerting them to hazards they may not have been familiar with."[198] Thus, he makes the point that multimedia messages are useful in conveying

193 Texas Disability Task Force on Emergency Management, 3.

194 Federal Emergency Management Agency, "PrepTalks: Dr. Dennis Mileti."

195 National Council on Disability, *Effective Emergency Management*, 39.

196 Francisco Sánchez, "Sanchez WEA Letter to FCC," July 10, 2017, https://ecfsapi.fcc.gov/file/1071068050241/FCC_ExParteLetter-SIGNED_7-10-17.pdf, cited in Tom Wheeler, "Hurricane Harvey Shows It Is Time for FCC to Improve Emergency Alerts," *Techtank* (blog), September 6, 2017, https://www.brookings.edu/blog/techtank/2017/09/06/harvey-hurricane-shows-it-is-time-for-fcc-to-improve-emergency-alerts/.

197 Wheeler.

198 Francisco Sánchez, "HCOHSEM WEA-Mulitmedia-Comment 05–2018," May 23, 2018, https://ecfsapi.fcc.gov/file/10523096137990/HCOHSEM_WEA-Mulitmedia-Comment_05-2018.pdf, as cited in Bean, *Mobile Technology*, 53.

information to message recipients in situations that may be challenging. He mentions, too, how this capability could allow messages to be conveyed via American Sign Language.[199]

The impacts on communication infrastructure from Hurricane Harvey were devastating and widespread, and underscore the area's limited resilience. Numerous sources document how poorly the infrastructure fared in the face of the hurricane.[200] Indeed, according to a Federal Communications Commission impact report for August 27, 2017, four counties had more than half of their cellular infrastructure taken out of commission by the storm.[201] Figure 7 provides a snapshot of impacts to cellular communications following Hurricane Harvey. Other forms of communications infrastructure were also impacted, such as cable television and radio stations; nine radio stations ceased to broadcast due to the storm and nearly 150,000 customers lost cable or similar television provision.[202]

[199] Bean.

[200] Thomas Frank, "Cell Phone Service Must Be Restored Quicker after Hurricanes," *Scientific American*, October 8, 2019, https://www.scientificamerican.com/article/cell-phone-service-must-be-restored-quicker-after-hurricanes/; Jon Brodkin, "Tropical Storm Harvey Takes Out 911 Centers, Cell Towers, and Cable Networks," Ars Technica, August 28, 2017, https://arstechnica.com/information-technology/2017/08/tropical-storm-harvey-takes-out-911-centers-cell-towers-and-cable-networks/; "Communications Status Report for Areas Impacted by TS Harvey," Federal Communications Commission, August 27, 2017, https://www.fcc.gov/document/communications-status-report-areas-impacted-ts-harvey.

[201] Federal Communications Commission, "Areas Impacted by TS Harvey," 3.

[202] Federal Communications Commission, 4.

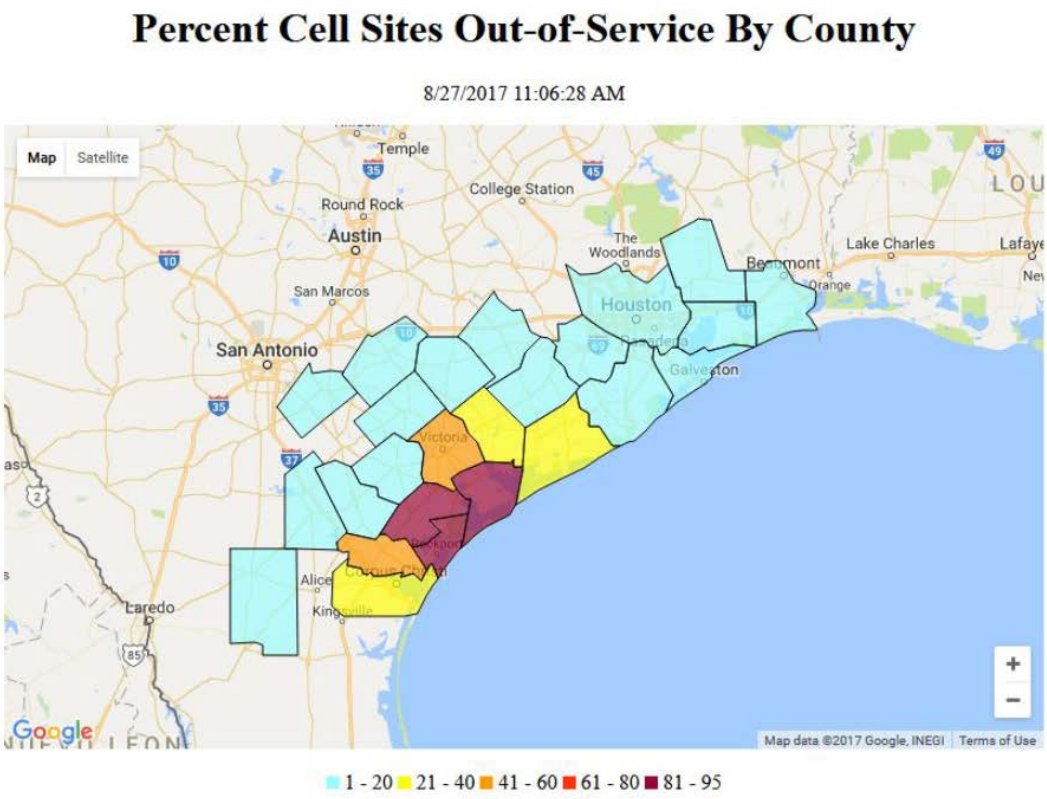

Figure 7. Cell Infrastructure Impacts from Harvey[203]

Importantly, however, the FCC had no indication that broadcast television had been impacted as of that date (27 August).[204] Such communication disruption is problematic for warning the public, as such media are avenues through which government alerting authorities send warnings. Indeed, the Emergency Alert System relies on television (cable and broadcast) and radio.[205] Additionally, Wireless Emergency Alerts rely on cellular broadcast technology.[206] Thus, the outages would have greatly hampered the ability to send warnings and notifications to the public regarding evacuations and other vital information.

[203] Source: Federal Communications Commission, 2.

[204] Federal Communications Commission, 4.

[205] Federal Emergency Management Agency, "Emergency Alert System (EAS)."

[206] Federal Emergency Management Agency, "IPAWS Architecture."

Another vital aspect of damage from the storm was the 9-1-1 centers or Public Safety Answering Points (PSAPS).[207] While this made it difficult for the public to contact 9-1-1 centers in the wake of Harvey, it also made it difficult for public safety agencies to reach the public.[208] Recent information from FEMA demonstrates just how many 9-1-1 emergency communications centers are authorized to disseminate such alerts.[209] These centers may also send alerts through local mass notifications systems as well.

2. Conclusion

Hurricane Harvey was incredibly destructive, and emergency warnings in the wake of the storm fell short in several areas. Individuals with disabilities may have been at a greater risk during the storm, and evidence supports a need for more public education, pre-planning, and coordination with such populations. Additionally, a need exists for more resilient infrastructure and updates for improved accessibility in current warning systems. The communications dynamic following Harvey may have delayed or prevented alerts from being sent to the public. This is even more detrimental for people with functional and access needs, as they may require more time to react after receiving an alert.[210]

Research conducted following Harvey has indicated that individuals with functional and access needs were more heavily grouped in areas most vulnerable to flooding in and around Houston.[211] While more research is needed, there could be implications from this study for negative impacts to such communities with regard to infrastructure, which could hamper emergency communications, including warnings and notifications. Correspondence from emergency management practitioners with the FCC shows that updates are needed for the Wireless Emergency Alerts system, which would facilitate more effectual communication with people with functional and access needs.[212]

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[207] Federal Communications Commission, "Areas Impacted by TS Harvey," 2.

[208] Texas Disability Task Force on Emergency Management, *Hurricane Harvey*, 3.

[209] "Organizations with Alerting Authority Completed," Federal Emergency Management Agency, May 28, 2020, https://www.fema.gov/media-library/assets/documents/117152.

[210] National Council on Disability, *Effective Emergency Management*, 39.

[211] Chakraborty, Grineski, and Collins, "Hurricane Harvey and People with Disabilities."

[212] Bean, *Mobile Technology*.

Lastly, an after-action report from the state of Texas focused specifically on Harvey-related issues for people with disabilities recommended bolstering pre-event planning and coordination between emergency management and functional and access needs groups to improve information flow during future incidents.[213] The report also identified a need for continued planning for improving warning inclusivity for such communities.[214]

This case study illustrates the simultaneous criticality and susceptibility of communications infrastructure. Indeed, this dynamic has already received attention following hurricanes such as Harvey.[215] It also illustrates that people with functional and access needs may face an increased danger simply because of where they reside, and that warning technology must be more inclusive and redundant to better serve those with disabilities. Continued dialogue and planning are also needed. Technology, both cutting-edge and archaic, must be utilized to ensure better inclusivity and reduce disruptions in vital emergency warnings. Better planning and coordination will also ensure the government is meeting the needs of some of its most vulnerable citizens.

D. LESSONS FROM U.S. CASE STUDIES

The Oroville Dam incident in 2017, the California wildfires in 2017 and 2018, and Hurricane Harvey in 2017 represent recent U.S. incidents in which warnings and notifications to the public shaped the outcome. Because warnings and notifications were important in these large incidents, emergency managers can glean many lessons. These case studies suggest warnings and notifications gaps for people with functional and access needs in the following areas:

- **Public education, outreach, and planning**: While proposed legislation holds some promise in this arena, such as California's Senate Bill 794, more work is needed to promote warning and notification systems to

213 Texas Disability Task Force on Emergency Management, *Hurricane Harvey*, 3–4.

214 Texas Disability Task Force on Emergency Management, 3.

215 Frank, "Cell Phone Service."

people with functional and access needs; for instance, emergency management agencies must work to promote registration for local mass-notification systems and to promulgate information about other systems. Such outreach may also bolster the confidence of vulnerable populations in public safety agencies and warning systems.[216]

- **Alert originator education and planning**: As the wildfires and Oroville demonstrate, more education on and planning for warnings on the part of alert originators is crucial. Mileti identifies that planning for this function is often wholly inadequate.[217]
- **Timeliness of warnings**: This particular aspect of warnings is of vital importance to people with functional and access needs, as they may have limited ability to quickly adhere to warning instructions.[218]
- **Reliance on too few systems:** When alert originators rely on too few warning systems, segments of the population may not receive the warnings. The academic literature supports this idea, as no single system is perfect.[219]
- **Wireless Emergency Alerts**: This system, which if often underused, has promise for people with access and functional needs. Local alert originators have called for updates to bolster the system's accessibility.
- **Resilience of current warning infrastructure**: The wildfires and Hurricane Harvey underscore the importance of resilient warning infrastructure.

These six broad gaps have numerous implications for people with functional and access needs, and solutions are explored in Chapters VI and VII.

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[216] Department of Homeland Security Analytic Exchange Program, *Communication Tools*, 19–20.

[217] Mileti, "Modernizing Public Warning Messaging," 20.

[218] National Council on Disability, *Effective Emergency Management*, 39.

[219] Mileti, "Modernizing Public Warning Messaging," 21; Department of Homeland Security Analytic Exchange Program, *Communication Tools*, 26.

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V. INTERNATIONAL CASES IN INCLUSIVE ALERTING: IDENTIFYING BEST PRACTICES

International case studies can guide practitioners in the United States, as they provide examples of how other countries solve similar problems with different resources. This chapter reviews the warning systems and methodologies of Canada and New Zealand. These countries face diverse hazards and have recently updated their warnings and notifications systems.

A. CANADA

This section focuses on Canada's current national warning program, a recent real-world incident, and accessibility practices. The conclusions are plugged into the value proposition in Chapter VI and support the overall recommendations in Chapter VII.

1. National Warning Methodology Overview

Canada has a national warning methodology that is similar to the Integrated Public Alert and Warning System in the United States. At least one scholar, Hamilton Bean, contends that the Canadian system is instructive for the American system; he draws parallels between the two and also highlights their differences.[220] The Canadian system is called the National Public Alerting System by government entities, but it is promoted as Alert Ready to those who might receive alerts.[221] Government agencies at different levels have the authority to activate the system, and numerous alerting channels compose it, such as cellular providers and traditional broadcast media.[222] As with similar services in other countries, Alert Ready is a public-private partnership.[223]

220 Bean, *Mobile Technology*, 120–23.

221 "National Public Alerting System," Public Safety Canada, April 6, 2018, https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/mrgnc-prprdnss/ntnl-pblc-lrtng-sstm-en.aspx.

222 Public Safety Canada.

223 Public Safety Canada.

While the broadcast components (television and radio) have been involved in alerting the public in Canada for some years, the mobile phone alerting element did not come online until 2018.[224] Known as the Wireless Public Alerting Service (WPAS), it sends text-like alerts to individuals in harm's way. However, it does not send a typical text message; it relies on the same technology as Wireless Emergency Alerts in the United States. According to the Alert Ready website, this system uses "Cell Broadcast . . . a mobile technology that allows messages to be broadcast to all compatible wireless devices within a designated geographical area. Cell Broadcast . . . is not affected by network congestion because it uses a dedicated part of the network, separate from that used for traditional voice and data traffic."[225] Alerts consist of a textual description of the hazard and other information, as well as an audible attention-grabbing noise; phones also vibrate when they receive an alert.[226] These wireless alerts, along with the television and radio broadcast components, are intended to reach a broad audience for a multitude of hazards and are meant to provide vital protective instructions to the public.[227]

2. Accessibility Practices

Canada's new alerting technologies have not been implemented without road bumps. As a recent incident in Nova Scotia illustrates (described in more detail below), even the best warning and notification systems are often limited by human action—or inaction—and, as others in the United States have found, it is important to use multiple channels to notify the public in emergencies. However, there are numerous positive lessons to glean from Canada as well. Specifically, the country uses methods that either directly or indirectly enhance the accessibility of alerts and notifications for those with functional or access needs. These methods include regular test alerts, bilingual alerting (English and

224 "Chronology: National Public Alerting in Canada," Public Safety Canada, April 6, 2018, https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/mrgnc-prprdnss/ntnl-pblc-lrtng-sstm-chr-en.aspx.

225 "Alert Ready—Frequently Asked Questions," Alert Ready Emergency Alert System, accessed May 2, 2020, https://www.alertready.ca/wireless/.

226 Alert Ready Emergency Alert System.

227 Alert Ready Emergency Alert System.

French), an easy-to-find public feedback portal for alerts, and an in-depth video series describing how Alert Ready works in American Sign Language .

On April 18 and 19, 2020, Nova Scotia experienced an active threats attack that ultimately killed over twenty people; based on news reports, the Canadian public safety officials did not issue alerts via the Alert Ready system.[228] However, Canadian officials did use other means to communicate with the public. The Royal Canadian Mounted Police (RCMP) used social media, specifically Twitter, to disseminate information about the attack.[229] See Figure 8 for a snapshot of the Tweets from this incident.[230] In an interview after the incident, RCMP Commissioner Brenda Lucki described the "dynamic nature" of the incident as one of the potential reasons the Alert Ready system was not used.[231]

[228] David Matthews, "Police Failed to Issue Timely Alert During Mass Shooting in Canada," *New York Daily News*, April 23, 2020, https://www.nydailynews.com/news/world/ny-nova-scotia-shooting-timely-alert-fail-20200423-3qqxwv2e3bdx5e4scm3icsit24-story.html.

[229] John Paul Tasker, "Questions Emerge about RCMP's Failure to Send Emergency Alert on Gunman's Rampage," CBC, April 21, 2020, https://www.cbc.ca/news/politics/questions-remain-rcmp-ns-emergency-alert-1.5540100.

[230] Royal Canadian Mounted Police Nova Scotia Twitter, April 18, 2020, https://twitter.com/rcmpns.

[231] Tasker, "Questions Emerge about RCMP's Failure."

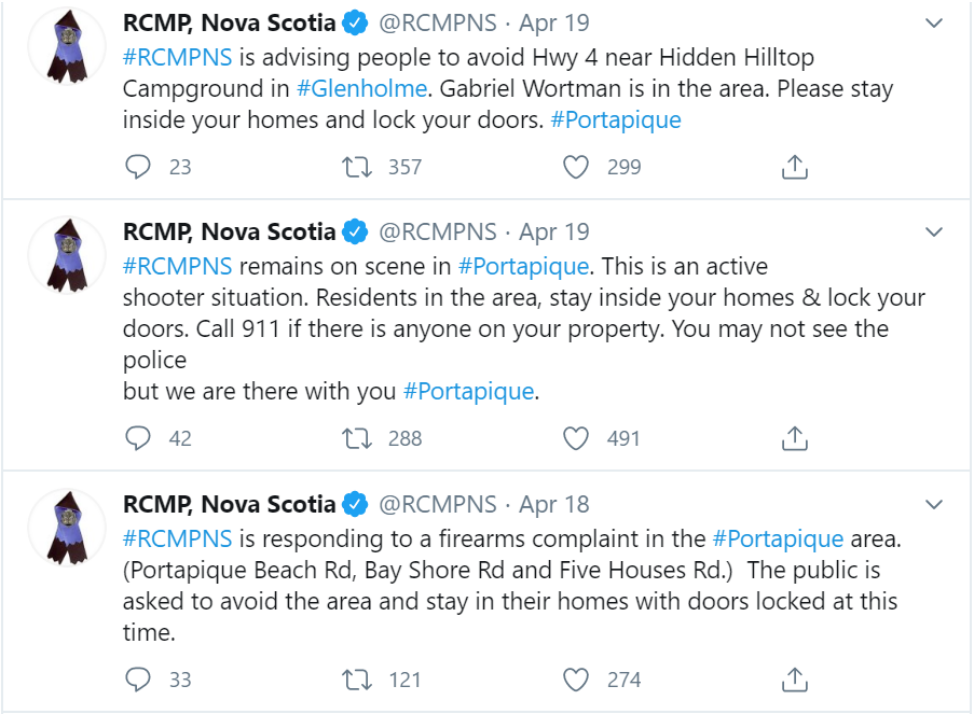

Figure 8. Tweets from RCMP Nova Scotia during Active Shooter Attack[232]

Unfortunately, not every constituent uses Twitter, and even those who do may not follow their police department or actively monitor their feed. Indeed, reliance on limited distribution channels is not recommended by alerting experts such as Dennis Mileti.[233] According to recent data from the Pew Research Center, the percentage of the population that uses Twitter declines with age; only 7 percent of U.S. adults aged 65 or older use Twitter.[234] This means that roughly 93 percent of this elderly in the United States, some of whom have functional and access needs, would miss information disseminated solely on Twitter. While traditional media outlets may report on information originally

[232] Source: Royal Canadian Mounted Police Nova Scotia Twitter, accessed May 3, 2020, https://twitter.com/rcmpns.

[233] Federal Emergency Management Agency, "PrepTalks: Dr. Dennis Mileti."

[234] Andrew Perrin and Monica Anderson, "Share of U.S. Adults Using Social Media, Including Facebook, Is Mostly Unchanged Since 2018," Pew Research Center, April 10, 2019, https://www.pewresearch.org/fact-tank/2019/04/10/share-of-u-s-adults-using-social-media-including-facebook-is-mostly-unchanged-since-2018/.

disseminated through social media, this does not happen quickly. Such delays are problematic in fluid public safety emergencies.

A more recent incident suggests that Canadian alert originators are becoming more familiar with Alert Ready. On July 17, 2020, the Ontario Provincial Police Tweeted about their first use of the warning system.[235] In the tweet, the department declares that its first activation of Alert Ready effectively warned the public about an "armed and dangerous person."[236] Canada also tests the Alert Ready system twice per year, including the wireless alerts component.[237] In the United States, however, the federal government has only publicly tested the Wireless Emergency Alert system once, in 2018. Bean asserts that such regular testing efforts help to "[e]nsure that citizens are knowledgeable about the system and prepared to respond to mobile messages."[238] These public, regularly scheduled test alerts improve familiarity with the systems for the general population, but also for those with functional and access needs. The Alert Ready website states that "[e]mergency alerts may be read to the recipient if your device supports this feature."[239] Therefore, regularly scheduled and pre-promoted public tests would give the visually impaired, along with other segments of the population, a chance to test their ability to receive alerts through their devices. This gives visually impaired cell phone users a chance to identify any issues with screen reader technology on their device before true disasters and emergencies.

Another promising alerting accessibility practice in Canada is a portal through which the public can ask questions or provide feedback.[240] This practice enables the Canadian public to work through issues and identify solutions by collaborating with alerting authorities. Additionally, it may also allow government alerting authorities to

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235 Ontario Provincial Police East Region (@OPP_ER), "1st Emergency Alert by the #OPP Using #AlertReady - a Success.," Twitter, July 17, 2020, https://twitter.com/OPP_ER/status/1284111432532078597.

236 Ontario Provincial Police East Region (@OPP_ER).

237 "Wireless Public Alerts," Alberta Emergency Alert, accessed May 3, 2020, https://emergencyalert.alberta.ca/content/about/wireless.html#faq20.

238 Bean, Mobile Technology, 123.

239 Alert Ready Emergency Alert System, accessed May 3, 2020, https://www.alertready.ca/.

240 Alert Ready Emergency Alert System.

change their practices based on public feedback. Feedback is also helpful from individuals who use assistive technologies, such as screen readers, to receive alerts. Such technology adds another layer of complexity, and the ability to troubleshoot problems with government officials is important.

The last example of Canada's practices is a sign language video series on the Alert Ready system, which was produced by the wireless service providers.[241] This series covers a host of aspects about the wireless alerts component of Alert Ready, in an accessible format for those who are hearing-impaired or deaf.

Canada has made great strides in recent years in the alerting arena, especially for those who have functional or access needs. While the implementation of the Alert Ready system has not been perfect, Canada offers many lessons to alerting authorities in other countries regarding accessibility and inclusivity practices.

B. NEW ZEALAND

1. National Warning Methodology Overview:

Based on the available literature, New Zealand has a similar warning and notification system to those of Canada and the United States. According to a government alerting document, New Zealand's alerting protocol serves the public in times of emergency through alerts to a variety of channels "such as digital road signs, text messages, cell broadcast messages (Emergency Mobile Alerts), app screens, as well as the ability to utilise maps and URLs referred from within single or multiple . . . messages."[242] While there are other components to the system, such as television and radio alerts, New Zealand's online preparedness literature prominently features the wireless part of this

241 Wireless Accessibility, accessed May 3, 2020, https://www.wirelessaccessibility.ca/.

242 New Zealand Ministry of Civil Defense & Emergency Management, *Common Alerting Protocol CAP-NZ*, Technical Standard [TS04/18] (Wellington, New Zealand: Ministry of Civil Defence & Emergency Management, 2018), 17, https://www.civildefence.govt.nz/assets/Uploads/publications/Common-Alerting-Protocol/Common-Alerting-Protocol-CAP-NZ-Technical-Standard-TS04-18-FINAL.pdf.

system, Emergency Mobile Alerts.[243] This alerting system comes already installed on certain phones; there is no sign-up or app involved.[244]

As with mobile alerting systems in other countries, New Zealand's system is geographically focused on areas most at risk in a given emergency, and government public safety entities are the alert senders for this system.[245] According to the New Zealand Ministry of Civil Defense and Emergency Management, government alerting authorities can disseminate warnings and notifications for a whole host of hazards, including severe weather, biological events, infrastructure disruptions, large fires, hazmat releases, health incidents, and law enforcement incidents.[246] As with the Canadian and U.S. systems, New Zealand's Emergency Mobile Alerts are not standard text messages but are transmitted via cellular broadcast.[247] This broadcast channel is robust and not as susceptible to delays as other avenues.

2. Accessibility Practices

New Zealand has a modern and comprehensive national alerting system, likely driven by the numerous hazards the country faces. While at least one media report has highlighted a delayed alert, New Zealand is continually advancing its warning methodology, including practices for individuals who have functional or access needs.[248] These practices include accessible public education information on alerts and notifications in numerous formats and languages, efforts to minimize technological and other known gaps, and a regular national testing campaign.

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243 "Emergency Mobile Alert," Get Ready, accessed October 18, 2020, https://getready.govt.nz/prepared/stay-informed/emergency-mobile-alert/.

244 New Zealand Ministry of Civil Defense & Emergency Management, *Common Alerting Protocol*.

245 "Emergency Mobile Alert Frequently Asked Questions (FAQ)," Get Ready, accessed October 18, 2020, https://getready.govt.nz/prepared/stay-informed/emergency-mobile-alert/ema-faqs/.

246 New Zealand Ministry of Civil Defense & Emergency Management, *Common Alerting Protocol*, 2.

247 New Zealand Ministry of Civil Defense & Emergency Management, 17.

248 Brianna McIlraith, "Fire and Emergency NZ Apologise for Delayed Emergency Alert after Hāwera Ammonia Leak," Stuff, February 21, 2020, https://www.stuff.co.nz/national/119695351/fire-and-emergency-nz-apologise-for-delayed-emergency-alert-after-hwera-ammonia-leak.

New Zealand's public education and outreach materials, at least online, are highly inclusive. For example, on the Emergency Mobile Alerts website, public education materials are available in twenty-four languages, and there is a video in New Zealand Sign Language.[249] This site also contains audio files on a whole host of preparedness subjects in ten different languages, including English.[250] However, unlike the United States and Canada, which can send bilingual cellular emergency alerts, New Zealand only has the capability of sending alerts in English.[251] Still, New Zealand's efforts are impressive. For example, the website has a page dedicated to people with functional and access needs, with sections for numerous languages, for people with hearing or vision impairments, and others.[252] The page references formal warnings and notifications under the hearing impairment section and also dedicates a section to the importance of neighborhood-based assistance for those with functional and access needs.[253] The page encourages these citizens to "[s]hare contact details [with neighbors] so you can get in touch if an emergency occurs."[254] This helps to ensure those with disabilities do not miss crucial alerts and notifications. Previous research has identified a lack of such person-to-person connections within functional and access needs communities, and it is an important area of necessary focus when it comes to preparedness.[255]

Additionally, New Zealand established a Mobile Emergency Alerts interactive portal through which the public can provide feedback to government alerting authorities.[256] As referenced with the Canadian example, such a portal can enable the

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249 Get Ready, "Emergency Mobile Alert."

250 "Advice for People with Special Requirements," Get Ready, accessed October 18, 2020, https://getready.govt.nz/prepared/special-requirements/.

251 Get Ready, "Emergency Mobile Alert Frequently Asked Questions (FAQ)."

252 Get Ready, "Advice for People with Special Requirements."

253 Get Ready.

254 Get Ready.

255 James D. White, "Employment Prospects in a Digital World" (paper presented at the Georgia Institute of Technology, Atlanta, GA, March 1, 2012), https://cacp.gatech.edu/sites/default/files/docs/CSUN%20Presentation%202012%20JDW%20Final.pdf.

256 "Emergency Mobile Alert Feedback," National Emergency Management Agency, accessed May 10, 2020, https://www.research.net/r/alert-feedback.

public to provide information about issues with previous alerts, including problems with assistive technologies, such as screen readers.

A local government in New Zealand has implemented another unique inclusivity practice: in Auckland, the emergency management program, working with partners, distributed cellphones to the indigent population so they could stay informed during the COVID-19 pandemic.[257] While the Auckland Council does not reference Emergency Mobile Alerts, if the devices they issued are compatible with the alert system, this would be yet another benefit from this program, especially since New Zealand has used Emergency Mobile Alerts during the pandemic.[258] The use of a warning system for a slower moving disaster, such as a pandemic, is often not the norm. However, in a video address to the public on Facebook, Prime Minister Jacinda Ardern discusses the use of the phone-based warning system to send COVID-19 information to the public, explaining that it was impossible to use the system without the warning alarm sounding on recipients' phones.[259] The public responses to Ardern's video were overwhelmingly positive.[260] The only negative comment pertaining to the system came from someone who said they did not receive the alert.[261] One news outlet in New Zealand indicated that the warning via the Emergency Mobile Alert system had been precommunicated to the public via New Zealand Civil Defence.[262]

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257 "Mobile Phones Keep Auckland's Homeless Community Connected," Auckland Council, April 13, 2020, https://ourauckland.aucklandcouncil.govt.nz/articles/news/2020/04/mobile-phones-keep-auckland-s-homeless-community-connected/.

258 Zane Small, "Jacinda Ardern Discussed Alternatives to 'Loud Honk' Covid-19 Mobile Phone Alert," Newshub, March 26, 2020, https://www.newshub.co.nz/home/politics/2020/03/jacinda-ardern-discussed-alternatives-to-loud-honk-covid-19-mobile-phone-alert.html.

259 Jacinda Ardern, "Evening Everyone. Thought I'd Jump Online and Answer a Few Questions as We All Prepare to Stay Home for the Next Wee While. Join Me If You'd Like!," Facebook, March 25, 2020, https://www.facebook.com/45300632440/videos/147109069954329/?__so__=channel_tab&__rv__=all_videos_card.

260 Ardern.

261 Ardern.

262 "Covid-19 Coronavirus Lockdown: Civil Defence Alert Sent to Mobile Phones," *NZ Herald*, March 25, 2020, https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12319899.

In a final example, unlike the United States, New Zealand has tested its Emergency Mobile Alerts system nationwide numerous times, including in 2017, 2018, and 2019.[263] This testing helps the general public understand the alerts and also provides education for members of functional and access needs communities; furthermore, it allows them to test the assistive technologies before actual disasters occur.

Overall, New Zealand has an impressive warning and notification program, with many good practices of inclusiveness, such as accessible public education materials, encouragement of public input about alerting systems, distribution of cellphones to underserved populations, and frequent testing of alerting systems.

C. CONCLUSIONS

While Canada and New Zealand use warning systems that are technologically similar to the Integrated Public Alert and Warning System in the U.S., they demonstrate practices of inclusivity worth noting for American alert originators. This is especially true for state and local alert originators as they play a vital role in the warning function in the United States. As such, these practitioners should consider the following practices demonstrated by Canada and New Zealand to bolster inclusivity in warnings:

- **Language inclusivity:** Government websites on warning education should contain material in languages other than English to meet the needs of constituents.
- **Assistive technologies:** Such websites should also contain information on assistive technologies for warnings and building neighborhood partnerships to benefit those with functional and access needs.
- **Testing of warning systems:** Public tests of warning systems should be conducted to increase familiarity with these systems amongst all segments of the population – Bean supports this idea for the U.S.[264]

263 "Nationwide Test of Emergency Mobile Alert," Get Ready, accessed May 10, 2020, https://getready.govt.nz/prepared/stay-informed/emergency-mobile-alert/nationwide-tests/.

264 Bean, Mobile Technology, 123.

- **Underserved populations:** Indigent populations may be cut off from warnings and cell phone distribution programs could help to overcome such barriers in times of disaster.
- **Alternative tools:** Using non-emergency channels, such as Jacinda Ardern's Facebook video, in conjunction with warning systems can aid in explaining the situation to the public.

While these case studies offer many beneficial takeaways for the United States, they also highlight lessons learned. The Canadian example reinforces the idea that over-reliance on any one system for warnings and notifications is detrimental, as in the case of the Twitter example for the Nova Scotia incident.[265]

[265] Mileti, "Modernizing Public Warning Messaging," 27.

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VI. APPLICATION OF VALUE PROPOSITION

The value proposition framework, as developed by Osterwalder et al., considers the needs of clients within the context of a company's functions or goods and thereby seeks to add worth through meeting those identified needs.[266] Beyond its application to the private sector, this framework is helpful for the development of services, such as public warnings, within government as well. The value proposition canvas, as shown in Figure 9, demonstrates the lessons suggested by both the U.S. and international case studies in the preceding chapters. The idea behind the canvas for this thesis is to identify the shortcomings of current warning methodologies for people with functional and access needs by considering real-world incidents. This canvas also defines the components of effective warning systems to better inform warning practitioners.

Warnings have two sides—the sender and the receiver. The improvement process must consider both of these groups. In Figure 9, people with functional and access needs are the customer segment (right half of the canvas) and the value proposition is effective warning systems (left half of canvas). The customer segment portion of the canvas is broken into three sections, customer jobs (what the customers are trying to do), customer pains in performing the jobs, and gains through which the customers might more easily accomplish the jobs. In the case of this canvas, these three sections are receiving effective warnings (customer jobs), ineffectual warning frameworks (customer pains), and traits of warnings that meet the needs of the customer segment (gains).

The value proposition segment of the canvas is also broken into three parts: products and services (which should make the lives of the customers easier), pain relievers (aspects of the good or service that address customer pains), and gain creators (benefits of the good or service that enable customer job improvements). In the case of this canvas, these are public warning systems (products and services), benefits of such systems that are effective (gain creators), and how such systems reduce or eliminate the inadequacies of the status quo (pain relievers).

266 Osterwalder et al., *Value Proposition Design*, 6–9.

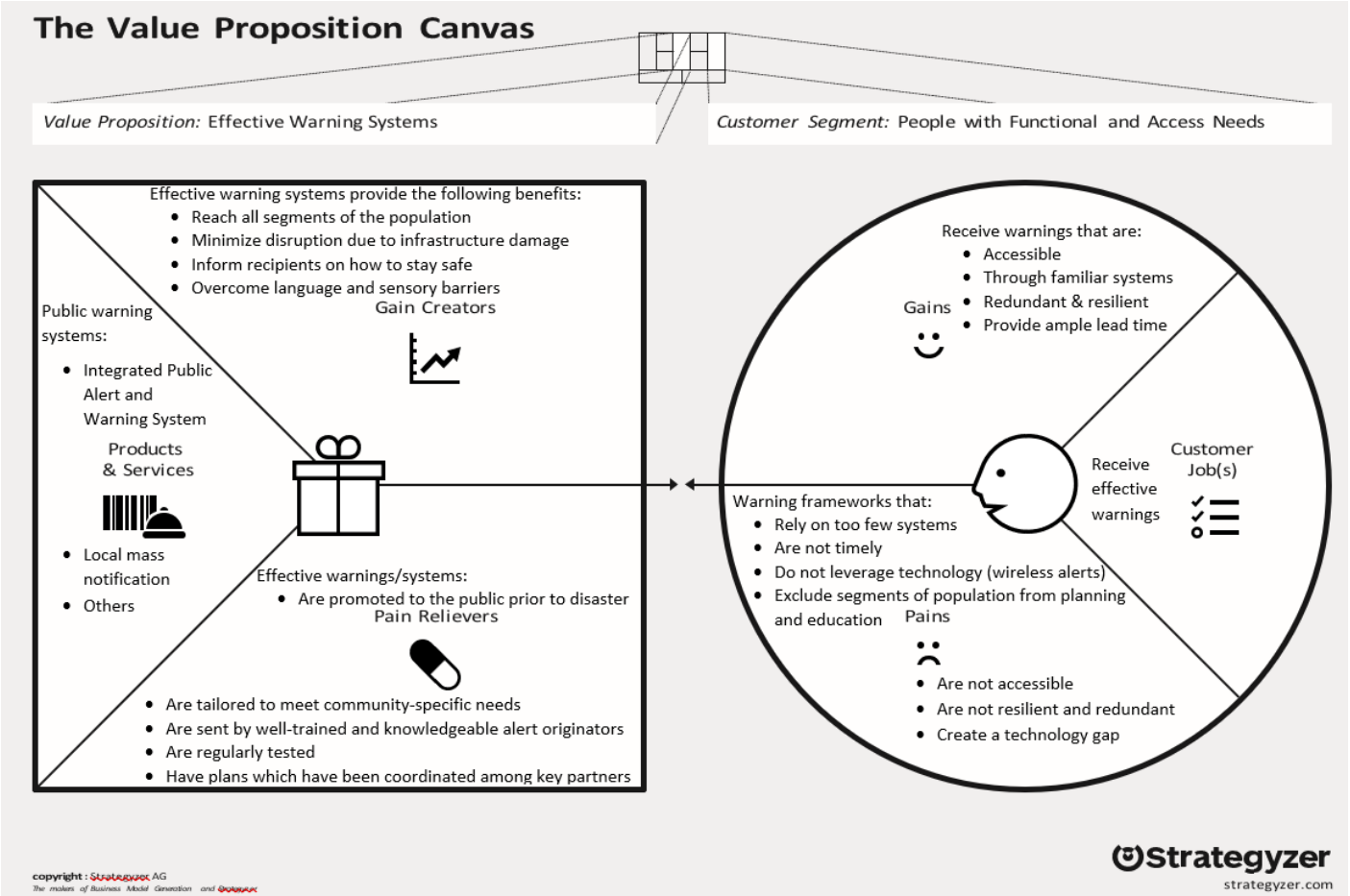

Figure 9. Value Proposition Canvas for Effective Warnings to People with Functional and Access Needs[272]

[272] Adapted from Strategyzer, "The Value Proposition Canvas."

So, what would a government alert originator that implements this value proposition canvas look like? Generally, the organization's leadership would support warning staff through planning, training, and education for multiple systems through resilient technologies. Although, when done effectively, this can consume a great many staff hours, an ideal alert originator would make the warning function a high priority. This is sometimes a challenge for jurisdictions that do not need to send warnings frequently. However, a proactive alerting authority would understand the vital importance of this function and dedicate appropriate resources to it. If effective warnings are not prioritized, it will be much harder to overcome barriers for the most vulnerable.

Once the organization has allocated sufficient resources, it should implement inclusive warning planning activities. The organization would need to understand the needs of its residents and overcome associated barriers. Such an understanding could only come from community-centered planning and coordination efforts and ongoing dialogue with functional and access needs organizations and individuals. This understanding could lead to more effective use of technology to meet community needs. Different communities have different demographics, resources, and challenges. Thus, there are nuances associated with adequately serving the needs of the community, state, etc. An ideal emergency management agency or other alert originator has a solid understanding of the demographics of the served constituency and any associated needs or barriers pertaining to warnings. Inclusive warnings are bolstered through inclusive planning.

Once the alert originator has allocated resources and implemented inclusive planning, the organization could leverage technology to overcome barriers to successful warnings. These technologies might look very different from one jurisdiction to another, depending on regional hazards and local needs. However, the organization would have numerous systems in place and would place a strong emphasis on resilience. Doing so acknowledges the academic work and case studies, which directly point to the drawbacks of an insufficient number of systems. The personnel charged with actually sending the warnings would need to be intimately familiar with the technology to ensure timely warnings, which are important for the general public but especially so for those with

functional and access needs. These attributes, and the lessons learned from the case studies, support the conclusions and recommendations in the next chapter.

VII. RECOMMENDATIONS, LIMITATIONS, AND CONCLUSIONS

This thesis applied a qualitative approach to the research by reviewing three U.S. case studies of disasters and two international case studies of inclusive alerting. It then applied the lessons from these cases to the value proposition canvas. This final chapter presents eight recommendations based on the application of these cases to the canvas and identifies limitations and areas for further research.

A. RECOMMENDATIONS

Public warnings are a complex, multifaceted function of public safety. These facets include technological, social, psychological, and incident-specific factors, to name a few. For vulnerable populations, such as individuals with functional and access needs, effective warnings may have even more barriers. Alert originators and other warning stakeholders must consider such factors, and the evidence from the academic literature and cases underscores the importance of the following recommendations. To facilitate future action for the improvement of warnings and alerts, the recommendations are grouped by stakeholder category, as one set of recommendations may fall within the purview of alert originators while others include stakeholders for financial incentives. These stakeholders have the authority to implement change within the recommendation area. The idea is to assign recommendations to the organizations best suited to effect change.

1. Local, State, and Federal Alert Originators, and Professional Associations

The following recommendations focus on action items for alert originators and they pertain to warnings and notifications, preparedness, education, and planning actions to make warnings more accessible and inclusive. Professional emergency management associations also have an important role within this arena, as they promote education and cooperative planning efforts for emergency managers and other alert originators. These organizations must collaborate with and actively listen to functional and access needs advocacy groups, as well as individuals with these needs, to fully realize success.

a. Educate Constituents on Warning Systems and Plan to Meet Community-Specific Needs

The case studies show the benefits of public education in warnings and warning systems. When there have been few outreach efforts, the efficacy of warnings has suffered. Additionally, these studies suggest that incorporating vulnerable populations into the warning planning process is vital. For example, a committee looking at lessons learned from Hurricane Harvey identified the need for a new role within state emergency management in Texas that would be dedicated to coordinating and planning for and with vulnerable populations.[273] This effort is praiseworthy and should be implemented elsewhere. Moreover, inclusive education and planning lead to inclusive warnings. Government outreach and education efforts, including educational materials for online warning systems, should meet community-specific needs for inclusivity as determined by collaboration, and should include different formats and languages.

Another consideration for accessibility of online warning educational literature is Section 508 of the Rehabilitation Act of 1973. Even if a government agency is not specifically mandated to adhere to these accessibility standards, agency leadership should consider doing so voluntarily.[274] \

Finally, warning originators should consider people experiencing indigence and their susceptibility in disasters, as did Auckland, New Zealand, during the COVID-19 pandemic.[275]

b. Educate and Train Alert Originators

While each incident is unique and some occur rapidly, alert originators must be able to disseminate clearly worded warnings expeditiously. Well-trained alert originators have a better chance of providing timely warnings and, thus, more forewarning for people with functional needs, who need more time to take the appropriate action—such as evacuating

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[273] Texas Disability Task Force on Emergency Management, Hurricane Harvey, 4.

[274] "IT Accessibility Laws and Policies," Section508.gov, accessed October 11, 2020, https://www.section508.gov/manage/laws-and-policies.

[275] Auckland Council, "Mobile Phones."

due to a wildfire or imminent dam failure. The summary from the National Emergency Management Association Wildfire Alert and Notification Workshop highlights the importance of well-trained alert originators, and so does the Woolsey Fire after action review.[276] Additionally, Mileti and the National Academies of Sciences, Engineering, and Medicine stress the importance of the language and specific instructions within warning communications.[277] The National Academies of Sciences, Engineering, and Medicine conclude, "Decades of work has identified that a variety of message characteristics—including content, style, length, delivery, and type of recommended protective action—influence public response."[278] The process is highly nuanced.

The case studies reviewed in this thesis highlight the varied levels of alert originator training and education. So too does Art Botterell, who explains, "We've yet to develop professional [warning] norms or a standard of practice to guide them [alert originators]. We have no institution to compile and analyze warning experience."[279] One potential avenue for this education is through warning seminars conducted by emergency management associations, facilitated by subject matter experts. These organizations may also have the ability to implement an alert credentialing program. Some of these organizations already have certified emergency manager designation programs, such as the Emergency Management Association of Ohio and the International Association of Emergency Managers.[280] A sub-designation or separate designation should be created for certified alert originators, based on criteria and standards developed within the membership of such organizations and by other subject matter experts.

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[276] National Emergency Management Association, "NEMA Wildfire Alert & Notification Workshop"; Citygate Project Team, *After Action Review of the Woolsey Fire Incident*, 87.

[277] Federal Emergency Management Agency, "PrepTalks: Dr. Dennis Mileti"; National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems*, 23.

[278] National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems*, 22.

[279] Bean, Mobile Technology, ix.

[280] "Ohio Certified Emergency Manager Program," Emergency Management Association of Ohio, January 8, 2010, http://www.emaohio.org/project-2/; "Certification Intro," International Association of Emergency Managers, accessed September 24, 2020, https://www.iaem.org/certification/intro.

c. Use All Warning Tools Available

The incident in Nova Scotia and the Woolsey Fire highlight that overreliance on any one system is detrimental and that social media, while powerful, are not a replacement for a warning system, such as Wireless Emergency Alerts or a local mass-notification system, to actively grab attention. The academic and practitioner literature supports the idea that the use of more systems is preferred. The Oroville Dam case illustrates that the public prefers to have numerous systems in place, as different individuals have different alerting requirements. Mileti, too, supports the idea that more systems are generally better for effective warnings.[281] Alert originators should use as many means to warn the public as possible to ensure a broader swath of the population receives the vital information. While nonemergency channels, such as social media, should not be used as standalone methods for warnings, Prime Minister Ardern has shown that social media use in conjunction with warning systems can help spread the word about emergency situations to the public.[282]

d. Leverage Assistive Technology

As technology progresses and more options become available for human interaction with devices, these technologies should be leveraged to make existing warning systems more accessible. The case studies, and numerous academic and practitioner documents, stress the importance of leveraging technology for inclusive alerting. Wireless Emergency Alerts hold a great deal of promise within this area, and FEMA continuously evaluates updates for the platform. One such promising development is that of hazards symbols (icons indicating the type of disaster or emergency, as shown in Figure 10), which may eventually accompany messages sent through Wireless Emergency Alerts.[283] FEMA states, "The symbols are designed to complement text and audio alerts distributed as EAS

[281] Mileti, "Modernizing Public Warning Messaging," 21.

[282] Ardern, "Evening Everyone."

[283] Federal Emergency Management Agency, *FEMA Integrated Public Alert and Warning System (IPAWS) 2018 Performance Report* (Washington, DC: Department of Homeland Security, 2019), 12, https://www.fema.gov/media-library-data/1563216905896-b4ffc85c1e7a43b9c8fbdd78fdee0723/IPAWS_Consolidated_Performance_Report_2018.pdf.

[Emergency Alert System] and WEA."[284] FEMA should be applauded for these efforts, and leadership must support such endeavors. Additionally, FEMA is working to add the functionality of warnings in languages other than just English.[285] At the end of 2019, FEMA implemented Spanish-language capability to the Wireless Emergency Alert system.[286] FEMA has also implemented other changes to the system that could make alerts more accessible.[287] However, there is more to accessible alerting than just Wireless Emergency Alerts.

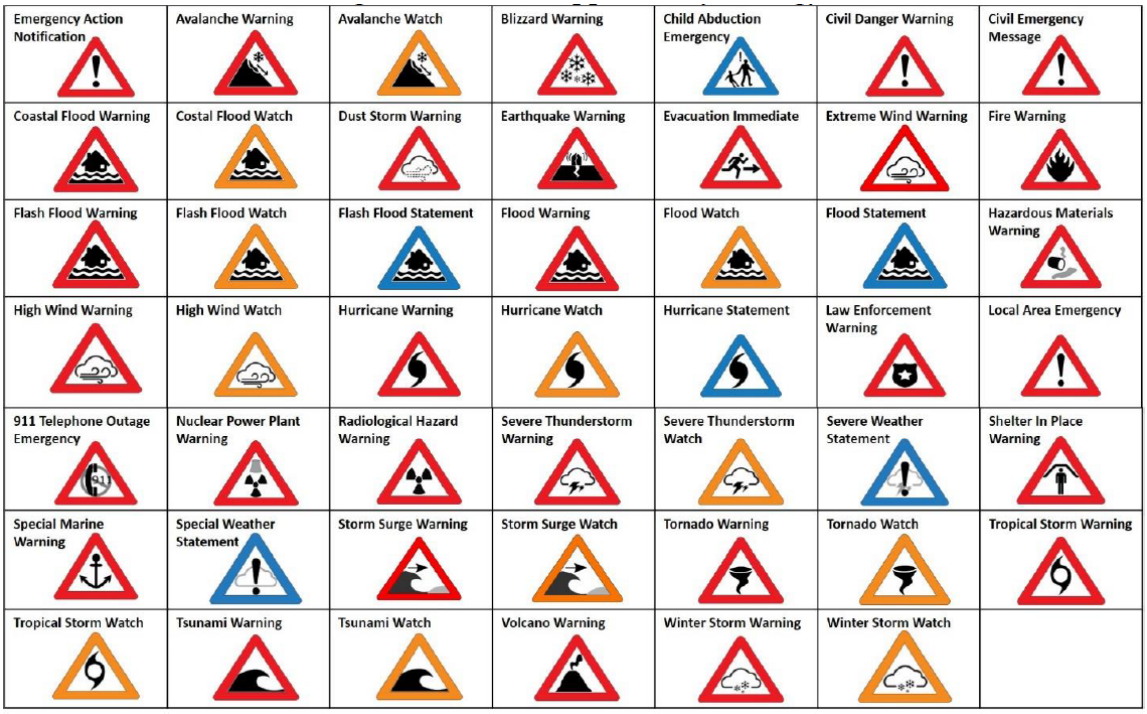

Figure 10. Potential Hazard Icons for Wireless Emergency Alerts[288]

284 Federal Emergency Management Agency, 12.

285 Federal Emergency Management Agency, 13.

286 "Wireless Emergency Alerts," Federal Emergency Management Agency, August 6, 2020, https://www.fema.gov/emergency-managers/practitioners/integrated-public-alert-warning-system/public/wireless-emergency-alerts.

287 Federal Emergency Management Agency.

288 Source: Federal Emergency Management Agency, 12.

Alert originators should work with functional and access needs advocacy groups and people who have additional barriers to effective warnings in the community to determine how assistive technologies might mesh with warning systems. As an example, NEMA has identified smart devices as a potential avenue through which the public might receive warnings.[289] The Wireless Inclusive Rehabilitation Engineering Research Center at Georgia Tech also continues to research how technologies worn on the person might increase the effectiveness of warnings for individuals with functional and access needs, as such technologies could help to overcome barriers.[290] Such research can serve as a guide for inclusive warning planning efforts.

e. Promote Know-Your-Neighbor Programs

The case studies and literature highlight the vulnerabilities of people with functional and access needs during disasters. James White discusses how these populations frequently have fewer personal connections, which can affect their disaster preparedness.[291] Indeed, according to Jonathan Garner et al., "There is evidence that vulnerable members of society who received help from family, neighbors, and their community were more likely to avoid potentially fatal weather events, whereas those who were socially isolated were more likely to succumb."[292] New Zealand's preparedness literature acknowledges the importance of such interpersonal affiliations within the context of information-sharing during disasters.[293] New Zealand's Get Ready website encourages citizens to "get to know [their] neighbors."[294] Due to this identified vulnerability and the power of neighborhood collaboration, emergency managers in the United States should

289 National Emergency Management Association, "NEMA Wildfire Alert & Notification Workshop," 7.

290 "Development Projects," Wireless RERC, accessed October 10, 2020, http://www.wirelessrerc.gatech.edu/development-projects.

291 White, "Employment Prospects in a Digital World."

292 Jonathan M. Garner et al., "A Multihazard Assessment of Age-Related Weather Vulnerabilities," *Weather, Climate, and Society* 12, no. 3 (May 8, 2020): 367, https://doi.org/10.1175/WCAS-D-19-0124.1.

293 New Zealand Ministry of Civil Defense & Emergency Management, "Advice for People with Special Requirements."

294 New Zealand Ministry of Civil Defense & Emergency Management.

encourage community preparedness through similar local programs. Such programs could have national and state emergency management support, and local agencies could tailor programs to fit the demographics of their communities, providing more social support for those who need it most in disasters.

f. Regularly and Publicly Test Warning Systems

The case studies and academic literature demonstrate the importance of regularly testing warning systems. Such tests benefit not only the general public but also those with functional and access needs. These tests complement inclusive outreach, education, and planning efforts, as disability advocacy groups can share information regarding tests with clients, and clients or caretakers can then ensure that accessible warning methods are in place in the home to meet the needs of a particular individual. Having an established means of coordinating with the public after such drills is important for gleaning information on potential warning improvements; the Department of Homeland Security supports this idea.[295]

2. FEMA and the Department of Homeland Security Science and Technology Directorate

The following recommendations incentivize local and state planning efforts and further research into resilient warning systems. The stakeholders for this area are those who can alter grant guidance and offer research awards.

a. Incentivize Emergency Management Planning Functions with Vulnerable Populations through Federal Grant Funding

In order to encourage alert originators to follow the previous recommendations, federal grant funding for emergency management should incentivize including vulnerable populations in the local and state emergency warning planning process. FEMA, as the administrator of numerous federal grant programs, should take the lead in this endeavor. A good candidate for such motivation is the Emergency Management Performance Grant,

[295] Department of Homeland Security, *Public Safety Communications*, 9.

which funds general emergency management activities in the United States.[296] To effectively accomplish such an incentive, FEMA should work with state emergency management agencies and solicit their feedback.

b. Conduct Further Research into Resilient Warning Infrastructure

The recent wildfires and hurricane illustrate just how vulnerable communications infrastructure currently is, despite advances in warning technology. More research is needed to bolster resiliency of warnings. The Department of Homeland Security Science and Technology Directorate should take the lead role in this endeavor, as the organization offers research funding for subjects pertaining to the homeland security enterprise, with one recent example focusing on COVID-19 technology.[297] One promising technology is the Radio Broadcast Data Service. As the case studies demonstrate, cellular infrastructure in its current state is susceptible to damage from disasters, which is problematic for alerts and warnings. However, Radio Broadcast Data Service (RBDS) relies on a separate backbone to operate: FM radio.[298] Thus, while recipients would still theoretically use the same devices (cellphones) to receive disaster-related information, a different set of infrastructure would send it to them.

The Wireless Inclusive Rehabilitation Engineering Research Center (known as Wireless RERC) has advocated for this technology as a method by which to bolster the resiliency and inclusivity of warnings.[299] Two studies, one from 2010 and one from 2014, have shown some promise for this technology, at least partially within the context of

296 "Emergency Management Performance Grant (EMPG)," FEMA, July 21, 2020, https://www.fema.gov/grants/preparedness/emergency-management-performance.

297 "DHS Awards $3.9 Million to Fund U.S. Small Business Research," Department of Homeland Security, June 9, 2020, https://www.dhs.gov/science-and-technology/news/2020/06/09/news-release-dhs-awards-39-million-fund-us-small-business-research.

298 Wireless RERC,"FM Radio and RBDS-Based Emergency Alerting," 8.

299 Wireless RERC.

functional and access needs message recipients.[300] Due to the age of these studies and lingering communications disruptions in disasters, more investigation is warranted, especially with recent advancements in the Integrated Public Alerts and Warning System. Such technology would provide another avenue through which to warn the public, even in the face of cellular disruptions. The Wireless RERC explains, "A cell phone with FM radio and/or RBDS text capability provides another method for all citizens to receive emergency information in the event cell service is unavailable. . . . Future use of the FM radio chip with RBDS could add functionality to turn on the phone automatically and present the alert information."[301] Thus, it could actively grab the user's attention.

The Wireless RERC further posits that RBDS could provide numerous benefits for people with functional and access needs, as such technology can circumvent many of the shortcomings of the cellular-based Wireless Emergency Alerts and could theoretically integrate with assistive technologies.[302] However, the Wireless RERC also recognizes that industry and technological hurdles exist for the implementation of this service, as envisioned.[303] That said, FM technology may still prove beneficial to cellphone users, even if the vision of fully integrated RBDS does not come to pass. Indeed, some cellphones can receive FM broadcasts, albeit with less inclusivity and warning functionality. The FM chips that enable such reception have received a fair amount of coverage.

The Wireless RERC also notes that FCC Chairman Ajit Pai has advocated for such technology.[304] Indeed, in a striking 2017 press release, Pai strongly encourages Apple to

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[300] Northrop Grumman Corporation, "Demonstration Report and RBDS Product Specification for Integrated Public Alert and Warning System (IPAWS) Radio Broadcast Data System (RBDS) Study," HSFEMW-09-F-0538 (report, Department of Homeland Security, 2010), https://www.fema.gov/media-library-data/1389287318308-1db8b2d1ef70462c148ba0623b18d78d/IPAWS+Radio+Broadcast+Data+System+(RBDS)+Study.pdf; Department of Homeland Security, "Accessible Common Alerting Protocol Radio Data System Demonstration: Gulf Coast States Final Report" (report, Department of Homeland Security, 2014), https://www.dhs.gov/sites/default/files/publications/Accessible-Common-Alert-Protocol-Radio-Data-Sys-Demo-GulfCoastStates-508.pdf.

[301] Wireless RERC, "FM Radio and RBDS-Based Emergency Alerting," 6.

[302] Wireless RERC, 10–11.

[303] Wireless RERC, 7.

[304] Wireless RERC, 5.

initiate FM technology within its cellphones.[305] The National Academies of Sciences, Engineering, and Medicine have also recognized the potential of marrying such technology within cellular devices as a way to bolster the resiliency of warning infrastructure.[306] This technology would act much like any other radio broadcast, as it could relay emergency or disaster information through regular and Emergency Alert System broadcasts if the user is actively listening. However, it would not actively grab users' attention if they are not listening to the broadcast.

Sam Matheny also highlights advantages of FM broadcast technology in a statement to Congress.[307] However, Matheny also discusses another broadcast technology that warrants further study for inclusive warnings, known as NextGen TV. Matheny elaborates, "a Next Gen TV signal could wake up enabled devices and. . . . Using the rich-media capabilities of Next Gen TV, broadcasters can provide targeted neighborhood-specific alerts that include text, graphics (such as Doppler radar animations or an evacuation route), pictures, and even detailed video-on-demand descriptions."[308] Furthermore, Matheny posits that this technology would continue to work even in the face of cell and power disruptions.[309] Thus, this technology is viewed as being resilient and its multimedia content could hold numerous benefits for people with functional and access needs. The U.S. Department of Homeland Security Science and Technology Directorate plays an important role in researching technology for use within the homeland security realm, and could aid in bolstering research with the aforementioned broadcast methodologies for robust and inclusive warning systems.

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305 "Chairman Pai Urges Apple to Activate FM Chips to Promote Public Safety," Federal Communications Commission, September 28, 2017, https://www.fcc.gov/document/chairman-pai-urges-apple-activate-fm-chips-promote-public-safety.

306 National Academies of Sciences, Engineering, and Medicine, *Emergency Alert and Warning Systems*, 52.

307 Ensuring Effective and Reliable Alerts and Warnings: Hearing before the Subcommittee on Emergency Preparedness, Response, and Communications of the Committee on Homeland Security House of Representatives, 115th Cong. 2 Sess. (statement of Sam Matheny, February 6, 2018), 43.

308 Ensuring Effective and Reliable Alerts, 42.

309 Ensuring Effective and Reliable Alerts, 42.

B. LIMITATIONS

This thesis was not meant to include an exhaustive examination of all the technical and human elements within the arena of effective warnings and alerts for people with functional and access needs; it merely scratched the surface. More research is needed to determine how best to serve these populations as technology continues to evolve. For example, research on RBDS and NextGen TV used in a complementary fashion with modern smartphones and Wireless Emergency Alerts would inform warning decision-makers on the costs and benefits of such potentially resilient warning systems. Additionally, such research should incorporate feedback from functional and access needs advocacy groups and individuals on whether RDBS and NextGen TV bolstering Wireless Emergency Alerts more adequately meets their warning needs.

Furthermore, the work of Chakraborty, Grineski, and Collins on the dangers posed to people with disabilities by Hurricane Harvey–related flooding around the Houston area is commendable; it would be illustrative for warning purposes to see if their findings generalize across the United States and all hazards.[310] If people with functional and access needs generally live in more disaster-prone, higher-risk areas across the nation, this dynamic would strongly underscore the importance of inclusive, resilient, and redundant warning systems. While this thesis did not thoroughly examine such data, further investigation is warranted.

C. CONCLUSION

The United States has a moral obligation to serve those who are most vulnerable in disasters, beyond its statutory and policy requirements. Previous after-action reports and academic literature point to these communities suffering inordinately in the face of disasters. Improving warnings and notifications for people with functional and access needs will undoubtedly make the United Stated a more disaster-resilient nation.

Those in public safety, emergency management, and homeland security must make accessible warnings a priority. Lives depend on it. As of this writing, massive wildfires are

[310] Chakraborty, Grineski, and Collins, "Hurricane Harvey and People with Disabilities."

again devastating the western United States and hurricanes are inundating the southern states. The year 2020 illustrated the need for effective warning systems. If current trends continue, there will be no shortage of hazards about which to warn the public. Investments of time, energy, and funding are vital in this arena, as such expenditures will pay dividends across all hazards and across all segments of the population, including the most vulnerable.

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